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**PROCEEDINGS 1967**

**Volume 1.**

AGENDA, PROGRAMME, REPORTS  
and PAPERS

**40th CONVENTION**

**15th to 18th May, 1967**

**LOURENCO MARQUES**

THE ASSOCIATION OF MUNICIPAL ELECTRICITY  
UNDERTAKINGS OF SOUTHERN AFRICA

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**VERRIGTINGS 1967**

**Deel 1.**

AGENDA, PROGRAM, VERSLAE  
en REFERATE

**40ste KONVENSIE**

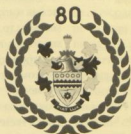
**15ste tot 18de Mei, 1967**

**LOURENCO MARQUES**

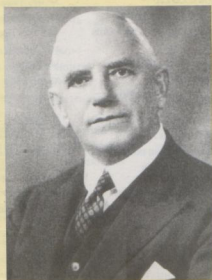
DIE VERENIGING VAN MUNISIPALE  
ELEKTRISITEITSONDERNEMINGS VAN SUIDELIKE AFRIKA

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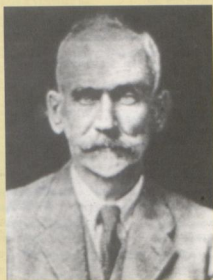
# Presidents of the Association of Municipal Electricity Undertakings (Southern Africa) 1915- 1995



## Presidente van die Vereniging van Munisipale Elektrisiteits Onderneming van Suidelike Afrika 1915-1995



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**THE ASSOCIATION OF MUNICIPAL ELECTRICITY  
UNDERTAKINGS OF SOUTHERN AFRICA  
NOTICE OF 40th CONVENTION**

Notice is hereby given that the 40th Convention of the Association will be held in Lourenco Marques at the venues set out in the Agenda and Programme issued herewith from 15th to 18th May, 1967, both days inclusive.

DAVIDSON & EWING (PTY.) LTD.

per: R. G. Ewing.

16th March, 1967.

Secretaries.

**AGENDA AND PROGRAMME  
40th CONVENTION**

**THEME:** "Engineering Knows No Boundaries"

**MONDAY, 15th May, 1967.**

- 10.00 a.m. Assemble for tea at City Hall.  
10.30 a.m. Assemble in Hall.  
10.45 a.m. Opening Prayer;  
Welcome to Lourenco Marques by the President, Camara Municipal, Lourenco Marques;  
Welcome to Convention by His Worship the Mayor of Vanderbijlpark;  
Official opening of the Convention by Mozambique Secretary for Public Works, Transport and Communications;  
Address by the Consul General of the Republic of South Africa in Mozambique;  
Induction of President;  
Presidential Address.
- 12 noon Luncheon Adjournment.
- 2.00 p.m. Registration at Conference Venue — Sociedade de Estudos.
- 2.30 p.m. Ratification of Actions of Executive Council;  
Election of President Elect;  
Amendments to Constitution;  
Election of Executive Council;  
Report of Secretaries.
- 4.00 p.m. Adjournment and Refreshment.
- 6.00 p.m. Cocktail Party — Vaco da Gama Gardens.

**TUESDAY, 16th May, 1967.**

- 9.00 a.m. Paper: "High voltage Circuit Breakers as applied to the National 400 K.V. Transmission System" by Mr. D. R. Duffield.
- 10.00 a.m. Discussion on Instantaneous Water Heaters.
- 10.30 a.m. Refreshment Interval.
- 11.00 a.m. Paper: "Research into Electrical Power Engineering and Related Subjects at the C.S.I.R.", by Messrs. R. B. Anderson and J. D. V. van Wyk.

**VERENIGING VAN MUNISIPALE ELEKTRISITEITS-  
ONDERNEMINGS VAN SUIDELIKE AFRIKA  
KENNISGEWING VAN 40ste KONVENSIË**

Hierby word bekend gemaak dat die Veertigste Konvensie van die Vereniging van Munisipale Elektrisiteitsondernemings van Suidelike Afrika vanaf 15 tot 18 Mei 1967, albei datums inbegrepe, te Lourenco Marques gehou sal word, op die vergaderplekke wat in die meegaande Sakelys en Program aangedui is.

DAVIDSON EN EWING (EDMS.) BPK.

per: R. G. Ewing.

16 Maart, 1967.

Sekretarisse.

**SAKELYS EN PROGRAM  
40ste KONVENSIË**

**TEMA:** "Die Ingenieurswese Ken Geen Grense Nie."

**MAANDAG, 15 Mei, 1967.**

- 10.00 vm. Vergader by die Stadsaal vir tee.
- 10.30 vm. Vergader in Saal.
- 10.45 vm. Opening met Gebed.  
Verwelkoming in Lourenco Marques deur die President, Camara Municipal, Lourenco Marques;  
Verwelkoming by die Konvensie deur Sy Agbare die Burgemeester van Vanderbijlpark;  
Ampelike Opening van die Konvensie deur Mosambiek se Sekretaris van Openbare Werke, Vervoer en Verbindinge;  
Toespraak deur die Konsul-Generaal van die Republiek van Suid-Afrika in Mosambiek;  
Inhuldiging van die President;  
Presidentsrede.
- 12 middag Verdagging vir Middagete.
- 2.00 nm. Registrasie by Konferensiesaal — Sociedade de Estudos.
- 2.30 nm. Bekragtiging van handeling van Uitvoerende Raad;  
Verkieping van Aangewese President;  
Wysiging van die Grondwet;  
Verkieping van Uitvoerende Raad;  
Verslag van die Sekretarisse.
- 4.00 nm. Verdagging en Verversings.
- 6.00 nm. Skemerpartytjie — Vasco da Gama-tuine.

**DINSDAG, 16 Mei, 1967.**

- 9.00 vm. Referaat: "Hoogspannings-stroombrekers soos in die Nasionale 400 kV.-Transmissiesistelsel Gebruik", deur Mnr. D. R. Duffield.
- 10.00 vm. Bespreking oor Blits-watervarmers.
- 10.30 vm. Pouse vir Verversings.
- 11.00 vm. Referaat: "Navorsing in Elektriese Krag-ingenieurswese en verwante rigtings in die W.N.N.R.", deur Mnr. R. B. Anderson en J. D. V. van Wyk.

- 12.30 p.m. Luncheon Adjournment.  
 2.30 p.m. Discussion on Report of Sub-Committees and Representatives.  
 3.30 p.m. Refreshment Interval.  
 4.00 p.m. Discussion on Papers.  
 5.00 p.m. Adjournment.  
 Evening: Concert at Radio Club or, alternatively, Cinema Show.

#### WEDNESDAY, 17th May, 1967.

- 9.00 a.m. Paperettes introducing visits to installations of interest:  
 (i) Gas Turbine Installation at Power Station of SONEFE.  
 (ii) Ore Loading Plant at Lourenco Marques Harbour.  
 10.30 a.m. Refreshment Interval.  
 11.00 a.m. Members' Forum — Councillor's Session — Administration and Delegation Problems — Introduced by Paper by Councillor M. G. Kipling.  
 12.30 p.m. Luncheon Adjournment.  
 Afternoon: Visits.  
 Evening: Free.

#### THURSDAY, 18th May, 1967.

- 9.00 a.m. Paper: "Some Aspects of Street Lighting" by Mr. J. W. Smit.  
 10.30 a.m. Refreshment Interval.  
 11.00 a.m. Members' Forum — Second Session —  
 (a) Portable Appliances fed from Socket Outlets — Introduced by Paper by Mr. A. F. Turnbull;  
 (b) Earth Leakage Protection applied to Overhead Lines and Domestic Installations — Introduced by Paper by Mr. H. P. Smith.  
 12.30 p.m. Luncheon Adjournment.  
 2.30 p.m. Members' Forum — Third Session — General.  
 3.30 p.m. Refreshment Interval.  
 4.00 p.m. Honorary Membership and Presentation of Insignia; Closing Session.  
 8.30 p.m. Buffet Dinner and Social Evening — Polana Hotel. Dress: Dinner Jacket or Lounge Suit.

- 12.30 nm. Verdaging vir Middagete.  
 2.30 nm. Bespreking van Verslae van Subkomitees en Verteenwoordigers.  
 3.30 nm. Pouse vir Verversings.  
 4.00 nm. Bespreking van Referate.  
 5.00 nm. Verdaging.  
 Aand: Konsert by Radio-klub of Bioskoopvertoning.

#### WOENSDAG, 17 Mei, 1967.

- 9.00 vm. Referaatjies ter inleiding van besoeke aan belangwekkende installasies:  
 (i) Gasturbine-installasies by SONEFE se Krag-sentrale.  
 (ii) Erts-laaï-installasie in die Hawe van Lourenco Marques.  
 10.30 vm. Pouse vir Verversings.  
 11.00 vm. Lede-forum — Sessie vir Raadslede — Vraagstukke van Administrasie en Delegasie — Ingelei met 'n Referaat deur Raadslied H. G. Kipling.  
 12.30 nm. Verdaging vir Middagete.  
 Namiddag: Besoeke.  
 Aand: Vry.

#### DONDERDAG 18 Mei, 1967.

- 9.00 vm. Referaat: "Enkele Aspekte van Straatverligting" deur Mnr. J. W. Smit.  
 10.30 vm. Pouse vir Verversings.  
 11.00 vm. Lede-forum — Tweede Sessie —  
 (a) Draagbare Toestella wat vanaf Kontakskokke gevoer word — Ingelei met 'n Referaat deur Mnr. A. F. Turnbull;  
 (b) Beskerming teen Aard-lekke, soos in Bo-grondse Lyne en Huishoudelike Installasies toegepas — Ingelei met 'n Referaat deur Mnr. H. P. Smith.  
 12.30 nm. Verdaging vir Middagete.  
 2.30 nm. Lede-forum — Derde Sessie — Algemeen.  
 3.30 nm. Pouse vir Verversings.  
 4.00 nm. Ere-lidmaatskap en Oorhandiging van Ordetekens. Slotsitting.  
 8.30 nm. Buffetedinee en Sosiale Aand — Hotel Polana. Kleredrag: Aandpakke of donker drapakke.

## LADIES PROGRAMME FOR THE CONVENTION

### MONDAY, 15th May, 1967.

- 10.00 a.m. Assemble for tea at City Hall.  
10.30 a.m. Assemble in Hall.  
10.45 a.m. Opening Prayer;  
Welcome to Lourenco Marques by the President of the Camara Municipal, Lourenco Marques;  
Welcome to Convention by His Worship the Mayor of Vanderbijlpark;  
Official opening of the Convention by Mozambique Secretary for Public Works, Transport and Communications;  
Address by the Consul General for the Republic of South Africa in Mozambique;  
Induction of President;  
Presidential Address.
- 12 noon Luncheon Adjournment.  
6.00 p.m. Cocktail Party — Vaco da Gama Gardens.

### TUESDAY, 16th May, 1967.

- 9.00 a.m. Tour of City — Ladies are requested to be ready at their hotels for transport to collect them by 8.45 a.m.
- Afternoon: Free.  
Evening: Concert at Radio Club, or alternatively, Cinema Show.

### WEDNESDAY, 17th May, 1967.

- Morning: Free.  
2.30 p.m. —  
4.30 p.m. Launch trip around Bay — Ladies are requested to be ready at their hotels to be collected by transport by 2.00 p.m.
- Evening: Free.

### THURSDAY, 18th May, 1967.

- Morning: Free.  
3.30 p.m. Assemble at Sociedade de Estudos for refreshments and Closing Session.  
8.30 p.m. Buffet Dinner and Social Evening — Polana Hotel. Dress — Evening (Long or Short Frocks).

## PROGRAM VIR DAMES GEDURENDE DIE KONVENSIE

### MAANDAG, 15 Mei, 1967.

- 10.00 vm. Vergader by die Stadsaal vir tee.  
10.30 vm. Vergader in Saal.  
10.45 vm. Opening met Gebed;  
Verwelkoming in Lourenco Marques deur die President van die Camara Municipal, Lourenco Marques;  
Verwelkoming by die Konvensie deur Sy Agbare die Burgemeester van Vanderbijlpark;  
Amptelike Opening van die Konvensie deur Mosambiek se Sekretaris van Openbare Werke, Vervoer en Verbindinge;  
Toespraak deur die Konsul-Generaal van die Republiek van Suid-Afrika in Mosambiek;  
Inhuldiging van die President;  
Presidentsrede.
- 12 middag Verdaging vir Middagete.  
6.00 nm. Skemerpartytjie — Vasco da Gama-tuine.

### DINSDAG, 16 Mei, 1967.

- 9.00 vm. Toer deur die Stad — Dames word versoek om teen 8.45 vm. gereed te wees om by hul hotelle opgelaaie te word.
- Namiddag: Vry.  
Aand: Konsert by die Radio-klub of Bioskoopvertoning.

### WOENSDAG, 17 Mei, 1967.

- Oggend: Vry.  
2.30 nm. —  
4.30 nm. Bootrit om die Baai — Dames word versoek om teen 2.00 nm. gereed te wees om by hul hotelle opgelaaie te word.
- Aand: Vry.

### DONDERDAG, 18 Mei, 1967.

- Oggend: Vry.  
3.30 nm. Vergader by die Sociedade de Estudos vir Versings en die Slotsitting.  
8.30 nm. Buffet-aandete en Sosiale Aand — Hotel Polana. Kleredrag — Aanddrag (lank of kort rokke).



## REPORT OF THE SECRETARIES

To the President and Members of the Association.

Mr. President, Gentlemen,

It gives me great pleasure to submit to you the Report of your Association for the two-year period ended 28th February, 1967.

### OBITUARY:

It is with great regret that we record the deaths of the following during the period covered by this report:

A. G. Kinsman, deputy City Electrical Engineer of Durban, an Engineer member of the Association.

Col. G. G. Ewer, Past President and Hon. Member of the Association.

G. A. Dalton, Associate Member.

P. C. Grandin, formerly Municipal Electrical Engineer of Gatooma, an Engineer Member of the Association.

H. J. Gripper, Municipal Electrical Engineer of Knysna, an Engineer Member of the Association.

### STRUCTURE OF THE ASSOCIATION:

Members are all aware of the circumstances which compelled the Executive Council to postpone the holding of the 40th Convention until 1967 and to hold a one-day Technical meeting in 1966. Arising from these events, I am now presenting to you for the first time, other than during the war years when the normal activities of the Association were suspended, a report covering a period of more than one year.

During the 40th Convention members will be asked to consider the adoption of an amended constitution for the Association which, apart from endeavouring to overcome shortcomings which have appeared over recent years, also regularises the position in regard to the holding of conventions other than annually. It is further proposed to amend the structure of the Executive Council in certain material respects and the attention of Regional Branches is drawn to the fact that under Clause 22(6) of the Proposed New Constitution, each Regional Branch is required to advise each convention prior to the election of the incoming Executive of the name of its representative on such incoming Council.

Dealing with languages, for the first time the draft Constitution now specifies that the Association accepts English and Afrikaans as its official languages. On this aspect, the policy of the Executive Council has long been to accept English and Afrikaans as the official languages of the Association and furthermore, to grant them equal status. There has been criticism from time to time in regard to the inequality in number of papers submitted to conventions in the two languages but at all times the Executive Council has endeavoured to secure papers in both languages. There has also been criticism of the standard of Afrikaans which has appeared in publications of the Association. Where this has taken place, we sincerely apologise for the shortcomings but wish to assure our friends, whether they be English or Afrikaans speaking,

## VERSLAG VAN DIE SEKRETARISSE

Aan die President en Lede van die Vereniging.

Mnr. die President en here,

Dit is vir my aangenaam om aan u die verslag van u Vereniging vir die tweejaar-tydperk wat op 28 Februarie 1967 geëindig het, voor te lê.

### DOODSBERIGTE:

Dit is met diepe leedwese dat ons aankondig dat die volgende persone gedurende die verslagtydperk oorlede is:-

A. G. Kinsman, Adjunk-Elektrotegniese Stadsingenieur van Durban, 'n Ingenieurslid van die Vereniging Kol. G. G. Ewer, Oud-President en Erelid van die Vereniging.

G. A. Dalton, Assosiaatlid.

P. C. Grandin, gewese Munisipale Elektrotegniese Ingenieur van Gatooma, 'n Ingenieurslid van die Vereniging.

H. J. Gripper, Munisipale Elektrotegniese Ingenieur van Knysna, 'n Ingenieurslid van die Vereniging.

### SAMESTELLING VAN DIE VERENIGING:

Lede is almal bewus van die omstandighede wat dit vir die Uitvoerende Raad nodig gemaak het om die 40ste Konvensie tot 1967 uit te stel en om gedurende 1966 'n eendaagse Tegniese Vergadering te hou. As gevolg van hierdie omstandighede lê ek nou aan u 'n verslag voor wat 'n tydperk van meer as 'n jaar dek. Die enigste ander keer toe dit gebeur het, was gedurende die oorlogsjare, toe die normale werksaamhede van die Vereniging opgeskort is.

Gedurende die 40ste Konvensie sal lede versoek word om oorweging te skenk aan die aanname van 'n gewysigde grondwet vir die Vereniging, wat nie alleen 'n poging is om die te kortkominge wat gedurende die afgelopen paar jaar tevoorskyn gekom het, reg te stel nie, dog wat ook die kwessie van die hou van tweejaarlikse konvensies regulariseer. Daar word verder voorgestel om die struktuur van die Vereniging in sekere wesentlike opsigte te wysig, en die aandaag van Streeks-takke word gevestig op die feit dat daar, ingevolge klousule 22(6) van die voorgestelde nuwe Grondwet, van elke Streeks-tak verwag sal word om elke Konvensie in kennis te stel van die naam van sy verteenwoordiger op die inkomende Bestuur voordat die Bestuur in werklikheid verkies word.

Wat die kwessie van taalgebruik betref, bepaal die Grondwet nou vir die eerste keer dat die Vereniging Engels en Afrikaans as sy amptelike tale aanvaar. Wat dit betref, was dit lankal die beleid van die Uitvoerende Raad om Engels en Afrikaans as die amptelike tale van die Vereniging te beskou en bowendien om gelyke status aan albei tale toe te ken. Daar is van tyd tot tyd kritiek uitgespreek oor die feit dat daar nie eweveel referate in die twee tale by konvensies van die Vereniging gelewer is nie, dog die Uitvoerende Raad het nog altyd probeer om referate in albei tale aan te bied. Daar was ook kritiek oor die standaard van die Afrikaans wat in publikasies van die Vereniging verskyn het. Waar dit wel ge-

that the endeavours of all concerned have been to secure, as far as possible, a completely bilingual Association. To assist further towards this end, the Standing Committee recently authorised the appointment of an official part-time translator to the Association and it is hoped that with his additional facility, cause for complaint in this direction will be completely overcome.

Another factor which has had to be considered by your Executive Council is the holding of meetings of the Executive Council. Restrictions now placed on local authorities sending their members to attend Executive Council meetings of Associations such as ours have proved exceedingly onerous in certain instances and steps have been taken whereby the absence from the home town of members of our Executive Council will be reduced to the absolute minimum.

### THIRTY-NINTH CONVENTION:

The 39th Convention of the Association was held in Port Elizabeth from Tuesday, 11th May to Friday, 14th May, 1965.

Delegates were welcomed to Port Elizabeth by His Worship the Mayor, Councillor Graham Young and the Official Opening of the Convention was performed by Dr. E. J. Marais, Principal of the University of Port Elizabeth, who presented a most thought-provoking and inspiring address. The total attendance of members, delegates, representatives, officials, visitors and ladies numbered 503.

The Convention marked the Golden Jubilee of the Association and on behalf of the President, members of the Association and all others who attended, our sincerest appreciation goes to His Worship the Mayor and City Councillors of Port Elizabeth for the outstanding hospitality extended on this memorable occasion in the annals of the Association. Appreciation is also expressed to His Worship the Mayor and members of the Town Council of Uitenhage for the hospitality extended by that town to those attending the Convention. Our sincere appreciation goes to the officials of Port Elizabeth for their contribution to the organisation of the convention. I have much pleasure in placing on record the appreciation of all for the efficient manner in which the President carried out his duties, not only at the convention, but throughout an unexpectedly long term of office. Grateful thanks are also extended to Mrs. Murray-Nobbs for her support and assistance.

The first paper to be presented to this Convention was "Transmission and Distribution Line Equipment" by Mr. A. A. Middlecote, S.A. Bureau of Standards. The paper which was up to the high standard of those previously presented to the Association by Mr. Middlecote will long remain a valuable contribution to the proceedings of the Association.

beur het, vra ons opreg verskoning vir enige tekortkominge en wil ons graag al ons vriende, of hulle nou ookal Afrikaans- of Engelsprekend is, die versekering gee dat alle betrokkenes opreg gepoeg het om sover moontlik te sorg dat die Vereniging ten volle tweetalig is. In 'n verdere poging om dit te verseker, het die Vaste Komitee onlangs die aanstelling van 'n amptelike deeltydse vertaler vir die Vereniging gemagtig, en daar word gehoop dat, met hierdie bykomende hulpmiddel, alle redes vir klages in hierdie verband nou heeltemal uitgeskakel sal word.

'n Ander saak wat deur die Uitvoerende Raad oorweeg moes word, is die kwessie van vergaderings van die Uitvoerende Raad. Die beperking wat nou op plaaslike besture geplaas is met betrekking tot die stuur van hulle lede om vergaderings van die Uitvoerende Rade van Verenigings soos ons s'n by te woon, het in sommige gevalle ernstige probleme opgelewer, en stappe is gedoen om die afwesigheid van lede van ons Uitvoerende Raad van hul tuisdorpe tot 'n absolute minimum te beperk.

### NEGE-EN-DERTIGSTE KONVENSIË:

Die 39ste Konvensie van die Vereniging is van Dinsdag, 11 Mei tot Vrydag, 14 Mei 1965 in Port Elizabeth gehou.

Die afgevaardigdes is in Port Elizabeth verwelkom deur Sy Agbare die Burgemeester, Raadslid Graham Young, en die amptelike opening van die Konvensie is waargeneem deur Dr. E. J. Marais, Rektor van die Universiteit van Port Elizabeth, wat 'n uiters prikkelende en inspirerende rede gelewer het. Die totale bywoning van die Konvensie deur lede, afgevaardigdes, verteenwoordigers, beamptes, besoekers en dames het 503 beloop.

By geleentheid van hierdie Konvensie is die Goue Jubileumsfees van die Vereniging gevier, en, namens die President, die lede van die Vereniging en alle ander aanwesiges, wil ons graag ons opregte waardering teenoor Sy Agbare die Burgemeester en die Stadsraadslede van Port Elizabeth betuig vir die besondere gasvryheid wat hulle by hierdie gedenkwaardige geleentheid in die geskiedenis van die Vereniging aan ons betoon het. Ons wil ook graag ons waardering teenoor Sy Agbare die Burgemeester en lede van die Stadsraad van Uitenhage uitspreek vir die gasvryheid wat deur daardie dorp aan diegene wat die Konvensie bygewoon het, gebied is. Ons hartelike dank gaan aan die munisipale beamptes van Port Elizabeth vir hul bydrae tot die organisasie van die Konvensie. Ook is dit vir my aangenaam ons almal se dank teenoor die President te boek te stel vir die bekwame wyse waarop hy sy pligte vervul het, nie alleen by geleentheid van die Konvensie nie, maar ook dwarsdeur sy onverwags verlengde dienstermyn. Ten slotte gaan ons innige dank aan Mev. Murray-Nobbs vir haar hulp en ondersteuning.

Die eerste referaat wat by hierdie Konvensie gelewer is, was "Transmission and Distribution Line Equipment", deur Mnr. A. A. Middlecote van die S.A. Buro vir Standaarde. Hierdie referaat, wat van dieselfde hoë standaard was as dié wat Mnr. Middlecote voorheen aan die Vereniging gelewer het, sal lank onthou word as 'n uitstekende bydrae tot die verrigtinge van die Vereniging.

The next paper to be presented was on "Transformer noise and its reduction in situ" by Prof. G. R. Brozzli, Professor of Electrical Engineering, University of Witwatersrand. This paper was a most authoritative contribution and evoked limited but interesting discussion.

The third paper presented to the convention was entitled "Some Notes on Tariffs" by Mr. W. Milton, Honorary Member and representative of ESCOM. The subject of tariffs always brings forth interesting discussion and this most informative paper by Mr. Milton was very well received.

The final paper was by Mr. M. J. Chappel of the Port Elizabeth Electricity Department and was entitled "Maintenance of a Distribution System". The paper was a practical one and was well received.

The Members' Forum was again appreciated and informative discussion on practical problems took place. Our thanks are extended to Mr. P. A. Giles for officiating as Quizmaster.

The social highlight of the Convention was the Jubilee Banquet and our thanks are extended to all who assisted in making this undertaking possible.

It was unanimously agreed that the 40th Convention of the Association be held in Lourenco Marques.

#### 1966 TECHNICAL MEETING:

The 1966 Technical Meeting of the Association was held on 2nd May in the City Hall, Bloemfontein. Our appreciation is extended to the City Electrical Engineer of Bloemfontein and his staff for their assistance and also to His Worship the Mayor of Bloemfontein and City Councillors for the hospitality extended to the Executive Council of the Association on the occasion of the meeting of the Council held to coincide with the Technical Meeting. In holding the Technical Meeting, the Association was breaking new ground and the total attendance of 117 persons was reasonably satisfactory although it was felt by those who did attend that the high standard of contributions and discussion thereon warranted greater support from the membership.

Papers presented were on "Earthing by means of conductors under foundations" by F. Stevens, Town Electrical Engineer of Ladysmith, "Earthing as defined in the Factories, Machinery and Building Work Act" by Mr. P. J. Botes, Town Electrical Engineer, Roodepoort, and "Electrical protection with special reference to earth leakage" by Mr. E. Tarchaski.

In addition, spirited discussion took place on Rights of Supply and the shortage of technical manpower.

#### MEMBERSHIP:

The following new members were elected during the two years ended 28th February, 1967:

#### Councillor Members:

Municipality of Fort Victoria  
Municipality of Koppies.

Die volgende referaat was getitel "Transformer Noise and its reduction in situ", deur Prof. G. R. Brozzli, Professor van Elektrotegniese Ingenieurswese aan die Universiteit van die Witwatersrand. Hierdie referaat was 'n uiters gesaghebbende bydrae en het beperkte dog interessante bespreking uitgelok.

Die derde referaat wat aan die Konvensie voorgelê is, was "Some Notes on Tariffs", deur Mnr. W. Milton, erlid en verteenwoordiger van EVKOM. Die kwessie van tariewe gee altyd aanleiding tot interessante bespreking, en hierdie hoogs insiggewende referaat van Mnr. Milton is baie goed ontvang.

Die laaste referaat is gelever deur Mnr. M. J. Chappel, van die Elektriese departement van Port Elizabeth, onder die titel "Maintenance of a Distribution System". Hierdie bydrae was prakties van aard en is goed ontvang.

Die Lede-forum was weer eens baie gewild en leersame besprekings oor praktiese probleme het plaasgevind. Ons wil graag ons dank aan Mnr. P. A. Giles betuig vir sy optrede as seremoniemeester by hierdie geleentheid.

Die sosiale hoogtepunt van die Konvensie was die Jubileumbanket, en ons wil graag almal bedank wat meegehelp het om hierdie onderneming moontlik te maak.

Daar is eenparig besluit dat die 40ste Konvensie van die Vereniging in Lourenco Marques gehou sal word.

#### TEGNIÛSE VERGADERING 1966:

Die TegniÛse Vergadering van die Vereniging vir 1966 is op 2 Mei in die Stadsaal, Bloemfontein, gehou. Ons wil graag ons dank betuig aan die Elektrotegniese Stadsingenieur van Bloemfontein en sy personeel vir hulle hulp, asook aan Sy Agbare die Burgemeester en lede van die Stadsraad van Bloemfontein vir die gasvryheid wat hulle betoon het aan die Uitvoerende Raad van die Vereniging by geleentheid van sy vergadering wat gehou is om met die TegniÛse Vergadering saam te val. Met die hou van die TegniÛse Vergadering het die Vereniging baanbrekerswerk gedoen en die totale bywoningssyfer van 117 persone was redelik bevredigend, alhoewel die aanwesiges die mening toegedaan was dat die hoë standaard van die bydraes en die besprekings 'n groter mate van ondersteuning deur die lede geregverdig het.

Die referate wat gelever is, het gehandel oor "Earthing by means of conductors under foundations", deur Mnr. F. Stevens, Elektrotegniese Stadsingenieur van Ladysmith, "Earthing as defined in the Factories, Machinery and Building Work Act", deur Mnr. P. J. Botes, Elektrotegniese Stadsingenieur van Roodepoort, en "Electrical protection with special reference to earth leakage", deur Mnr. E. Tarchaski.

Hierbenevens het daar lewendige besprekinge plaasgevind oor Voorsieningsregte en die tekort aan tegniÛse mannekrag.

#### LIDMAATSKAP:

Die volgende nuwe lede is gedurende die twee jaar geëindig 28 Februarie 1967 verkies:

#### Rade-lede:

Die Munisipaliteit Fort Victoria.  
Die Munisipaliteit Koppies.

Messina Health Committee  
Municipality of Bredasdorp  
Municipality of Saldanha

**Engineer Members:**

D. H. Fraser (Deputy City Electrical Engineer, Durban)  
J. E. Heydenrych (Middelburg, Transvaal)  
W. F. Cronje (Peri-urban Areas Health Board)  
J. C. Strauss (Sasolburg)  
G. van Niekerk (Vryheid)  
N. G. Hosking (Deputy General Manager, Johannesburg)  
E. Buchanan (Lydenburg)  
J. F. McHutchon (Asst. City Electrical Engineer, Cape Town)  
A. C. MacLaghlan (Saldanha)  
E. D. Pike (Kokstad)  
F. H. Robertson (George)  
J. W. Hough (Deputy Town Electrical Engineer, Brakpan)  
A. H. L. Fortman (Deputy Town Electrical Engineer, Boksburg)  
H. A. L. Louw (Assistant Town Electrical Engineer, Paarl)  
E. P. E. W. Trautmann (Lydenburg)

**Associates:**

A. Mc D. Wilson (Fort Victoria)  
N. J. de Jager (Thabazimbi)  
J. Clarke (Que Que)  
V. G. Flint (Koppies)  
P. M. Jooste (Official in Charge, Electricity Undertakings, Messina)  
J. G. Hugo (Bredasdorp)

**Technical Associate:**

W. Barnard (Asst. General Manager (Technical Administration) Johannesburg)

**Associate Members:**

D. P. de Wet (Groot Brak Rivier)

**Affiliates:**

T.P.H. Engineering (Pty.) Ltd.  
Cullinan Refractories Ltd.  
Minnesota Mining & Manufacturing Co. S.A. (Pty.) Ltd.  
Balledon & Robb  
G. W. Wiehahn  
North & Robertson (Pty.) Ltd.

**Transfer:**

W. G. Thackwray — transferred from Engineer Member to Associate Member on retirement.

The following resignations took place during the period under review:-

**Counciller Members:**

Town Council of Livingstone  
Gatooma Municipality

Die Gesondheidsraad van Messina.  
Die Munisipaliteit Bredasdorp.  
Die Munisipaliteit Saldanha.

**Ingenieur-lede:**

D. H. Fraser (Adjunk Elektrotegniese Stadsingenieur, Durban)  
J. E. Heydenrych (Middelburg, Transvaal)  
W. F. Cronje (Raad vir die Ontwikkeling van Buitestedelike Gebiede)  
J. C. Strauss (Sasolburg)  
G. van Niekerk (Vryheid)  
N. G. Hosking (Adjunk Algemene Bestuurder, Johannesburg)  
E. Buchanan (Lydenburg)  
J. F. McHutchon (Assistent Elektrotegniese Stadsingenieur, Kaapstad)  
A. C. MacLaghlan (Saldanha)  
E. D. Pike (Kokstad)  
F. H. Robertson (George)  
J. W. Hough (Adjunk Elektrotegniese Stadsingenieur, Brakpan)  
A. H. L. Fortman (Adjunk Elektrotegniese Stadsingenieur, Boksburg)  
H. A. L. Louw (Assistent Elektrotegniese Stadsingenieur, Paarl)  
E. P. E. W. Trautmann (Lydenburg)

**Geassosieerdes:**

A. Mc D. Wilson (Fort Victoria)  
N. J. de Jager (Thabazimbi)  
J. Clarke (Que Que)  
V. G. Flint (Koppies)  
P. M. Jooste (Beampte in Bevel, Elektrisiteitsondernemings, Messina)  
J. G. Hugo (Bredasdorp)

**Tegniese Geassosieerde:**

W. Barnard (Asst. Algemene Bestuurder (Tegniese Administrasie) Johannesburg)

**Assosiaatlade:**

D. P. de Wet (Groot-Brakrivier)

**Geaffilieerdes:**

T.P.H. Engineering (Pty.) Ltd.  
Cullinan Refractories Ltd.  
Minnesota Mining & Manufacturing Co. S.A. (Pty.) Ltd.  
Ballendon & Robb  
G. W. Wiehahn  
North & Robertson (Pty.) Ltd.

**Oorplasing:**

W. G. Thackwray — by aftrede oorgeplaas van Ingenieur-lidmaatskap na Assosiaatlidmaatskap

Die volgende het gedurende die verslagtyperk as lede bedank:-

**Rade-lede:**

Stadsraad van Livingstone  
Die Munisipaliteit Gatooma

## Engineer Members:

C. F. Hafele  
W. Beesley

Comparative membership figures are as follows:-

	As per previous Report	Including admissions as confirmed by Executive Council up to 25/11/66
Councillor Members	135	138
Engineer Members	116	125
Honorary Members	15	14
Associate Members	30	31
Associates	15	19
Affiliates	84	90
Retired Members	2	3
Technical Associates	Nil	1

## FINANCE:

The Income and Expenditure Accounts for the years under review which, together with the Balance Sheets as at 28th February, 1966 and 1967, will be considered at the 40th Convention. In order not to delay the publication of this Report, the accounts are not being issued therewith, but will be made available to members later. A satisfactory balance between Income and Expenditure will be reflected on the consolidation of the accounts in question.

In regard to the Proceedings, my last report referred to the fact that from the 1965 Proceedings these would be subject to editing with a view to omitting all irrelevant matter. It was subsequently decided that in addition, the papers, reports, etc., which are published prior to a convention or technical meeting should not be reprinted in the Proceedings. These two decisions have resulted in very considerable savings being effected. The co-operation of members in retaining for permanent record the documents published prior to a meeting will be greatly appreciated.

I wish to convey sincere thanks to the members of the Finance Committee, Mr. R. W. Leishmann (convener) and Mr. G. C. Lombard, for their assistance during the past two years.

## REGIONAL BRANCHES:

The period under review has seen the expansion of the Regional Branch structure with the formation of the Good Hope and Rhodesian Branches. It is regretted that it has not yet been found possible to establish a branch to handle the Orange Free State and certain areas contiguous thereto.

## MID-YEAR EXECUTIVE MEETINGS:

The Mid-year Executive Meetings held in 1965 and 1966 took place in Vanderbijlpark and Johannesburg respectively. On behalf of the President and Executive Council, sincere

## Ingenieur-lede:

C. F. Hafele  
W. Beesley

Die vergelykende lidmaatskapsyfers is soos volg:-

	Volgens vorige verslag	Met insluiting van lidmaatskapsyfers Uitvoerende Raad bekroeg tot 25/11/66
Rade-lede	135	138
Ingenieur-lede	116	125
Ere-lede	15	14
Assosiaatlede	30	31
Geassosieerdes	15	19
Geaffilieerdes	84	90
Afgetrede Lede	2	3
Tegniese Geassosieerdes	Geen	1

## GELDSAKE:

Die state van Inkomste en Uitgawe vir die verslagjare, tesame met die Balansstate soos op 28 Februarie 1966 en 1967, sal by geleentheid van die 40ste Konvensie oorweeg word. Teneinde nie die publikasie van hierdie verslag te vertraag nie, word die rekeningstate nie hiermee saamgestuur nie, dog dit sal later aan lede beskikbaar gestel word. By die konsolidasie van die betrokke rekeninge sal dit blyk dat die inkomste en uitgawe bevredigend met mekaar vergelyk.

Wat die notule van die verrigtinge betref, sal dit herinner word dat in my vorige verslag versyds is na die feit dat die notule in die toekoms gereediger sal word met die oog op die uitskakeling van alles wat nie ter sake is nie. Daar is later ook besluit dat die referate, verslae, ens., wat voor die Konvensie of die Tegniese Vergadering gepubliseer word, ook nie saam met die notule herdruk sal word nie. Hierdie twee besluite het daartoe gelei dat daar aansienlike besparings teweeggebring kon word. Die samewerking van lede deur die stukke wat voor 'n vergadering gepubliseer word, permanent te bewaar, sal baie hoog op prys gestel word.

Ek wil graag my innige dank oorbring aan die lede van die Komitee vir Geldsake, Mnr. R. W. Leishmann (Same-roeper) en Mnr. G. C. Lombard, vir hulle hulp en samewerking gedurende die afgelope twee jaar.

## STREEKSTAKKE:

Die streekstak-struktuur is gedurende die verslagtydperk uitgebrei deur die stigting van die takke Goëie Hoop en Rhodesië. Dit is jammer dat dit tot dusver nie moontlik was om 'n tak daar te stel om die sake van die Vrystaat en sekere aanliggende gebiede te behartig nie.

## HALFJAARLIKSE VERGADERINGS VAN DIE UITVOERENDE RAAD:

Die halfjaarlikse vergaderings van die Uitvoerende Raad gedurende 1965 en 1966 is onderskeidelik in Vanderbijlpark en Johannesburg gehou. Namens die President en die Uit-

thanks are conveyed to His Worship the Mayor of Vanderbijlpark, His Worship the Mayor of Johannesburg and the Councillors of both Vanderbijlpark and Johannesburg for the hospitality extended to the Executive on these occasions.

#### **SUB-COMMITTEES AND REPRESENTATIVES:**

The work of the various technical sub-committees of the Association as well as our representatives on other organisations continues to increase and it is not an easy task to convey adequately the debt members owe to these committee members and representatives for their unstinted efforts.

More and more, the Association is being called upon, often at short notice, to assist other bodies or to submit direct recommendations or proposals on matters of great importance to Electricity Undertakings. Those who are called upon to bear the brunt of this work are always available and somehow find it possible to find time and assist in the work of the Association. Our grateful thanks are due to them.

In order to streamline procedure within the Association, it was decided during the period under review to establish a Standing Committee consisting of the President, the immediate Past-President, the President-elect, together with their respective Councillor representatives and the Secretaries, ex officio. This committee is proving of considerable assistance in dealing with matters of urgency.

#### **SOUTH AFRICAN NATIONAL COMMITTEE ON ILLUMINATION**

For some years there have been thoughts on the most advantageous method by which close liaison could be established between SANCI and our Association. I am very pleased to be able to report that during the period under review it has been agreed that reciprocal membership be entered into between these two organisations. It is felt that only good can come of this co-operation between our respective bodies.

R. G. EWING,  
for Davidson & Ewing (Pty.) Ltd.  
Secretaries.

7th March, 1967.

voerende Raad wil ek graag ons opregte dank oorbring aan Sy Agbare die Burgemeester van Vanderbijlpark, Sy Agbare die Burgemeester van Johannesburg en die Stadsraadslede van sowel Vanderbijlpark as Johannesburg vir hul gasvryheid teenoor die Uitvoerende Raad by hierdie geleentehede.

#### **SUBKOMITEES EN VERTEENWOORDIGERS:**

Die werksaamhede van die subkomitees van die Vereniging, sowel as dié van die Vereniging se verteenwoordigers op ander organisasies, neem nog steeds toe, en dit is nie 'n maklike taak om voldoende uitdrukking te gee aan die dank wat ons lede aan hierdie komiteede en verteenwoordigers vir hul onvermoede ywer verskuldig is nie.

Die Vereniging word in 'n toenemende mate gevra, dikwels met kort kennisgewing, om ander liggame behulpsaam te wees of om direkte aanbevelings of voorstelle in te dien omtrent sake wat vir Elektrisiteitsondernemings van die grootste belang is. Diegene wat geroepe is om die grootste gedeelte van hierdie werk te doen, is altyd beskikbaar en vind op die een of die ander wyse die nodige tyd om met die werk van die Vereniging behulpsaam te wees. Ons is veel dank aan hulle verskuldig.

Met die oog op die stroombelyning van die interne werking van die Vereniging, is daar gedurende die verslagtydperk besluit om 'n Vaste Komitee in die lewe te roep, wat bestaan uit die President, die pasafgetrede President, die aangewese President, tesame met hulle onderskeie Raadsverteenvoerders, en die Sekretarisse amfshalwe. Daar is reeds bewys dat hierdie Komitee van veel waarde en hulp is, veral by die afhandeling van dringende sake.

#### **SUID-AFRIKAANSE NASIONALE KOMITEE VIR VERLICHTING:**

Daar is reeds die afgelope aantal jare gedagtes gewissel oor die mees voordelige wyse waarop daar noue skakeling tussen die Suid-Afrikaanse Nasionale Komitee vir Verligting en hierdie Vereniging bewerkstellig kan word. Dit is vir my besonder aangenaam om te kan verslag doen dat daar gedurende die verslagtydperk besluit is om wederkerige lidmaatskap tussen die twee liggame te reël. Daar word gemeen dat uit hierdie samewerking tussen ons onderskeie liggame slegs goeie dinge gebore kan word.

R. G. EWING,  
namens Davidson & Ewing (Edms.) Bpk.  
Sekretarisse.

# HIGH-VOLTAGE CIRCUIT-BREAKERS AS APPLIED TO THE NATIONAL 400kV TRANSMISSION SYSTEM

by D. R. DUFFIELD, B.Sc. (Eng.)

## 1. INTRODUCTION

Early in 1963 the decision was taken to use a voltage of 400 kV to transmit power generated at the Electricity Supply Commission's 1600 MW Camden power station in the Eastern Transvaal to the Witwatersrand load centres. Some eighteen months later plans to extend the 400-kV transmission system southwards to the Cape were formulated, and more recently, with the commencement of work on Hendrina power station (2000 MW) and Arnot power station (2100 MW), both on the Eastern Transvaal coalfields, further transmission at this voltage has been planned from these stations to points in the Pretoria and Reef areas and from Camden to Natal.

Fig. 1 illustrates the extent of the proposed 400-kV network. The overall length of the transmission lines to the Cape is in excess of 900 miles. The map shows the position of the major distribution stations that are to be established in the system. Confining attention to those on the Cape lines, for which plans are well advanced or on which work has already commenced, there is

Atlas, near Vereeniging, a major inflect point to the "Vaal Triangle"

Perseus, roughly equidistant from Kimberley and Bloemfontein

Hydra, near De Aar, which will link with the power stations of the Orange River Scheme at 132-kV

Droërivier, near Beaufort West, an important traction supply point, and

Muldersvlei, the terminal substation some 20 miles from Cape Town.

The longest lines will be between Droërivier and Muldersvlei where the route length between substations is approximately 261 miles.

The object of this paper is to discuss the specification and selection of circuit-breakers for this national 400-kV transmission system.

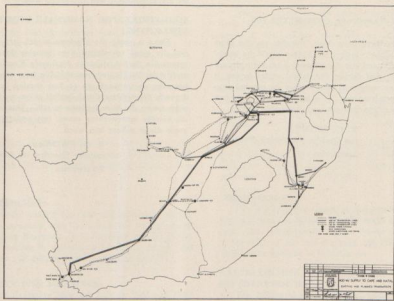


Fig. 1

## 2. THE SPECIFICATION OF HIGH VOLTAGE CIRCUIT-BREAKERS

Apart from the voltage, maximum load current and short-circuit ratings of a high voltage circuit-breaker, all of which are fixed by the system, taking into account, as far as possible, its ultimate developments, careful consideration must also be given to the following:-

- The rate of rise of restriking voltage (rrrv) appearing across the open circuit-breaker contacts immediately following arc extinction under all possible fault conditions.
- Short-line faults.
- Asynchronous conditions.
- Conditions likely to give rise to severe switching overvoltages.

### 2.1) Rate of rise of restriking voltage

Much has been written on the subject of system rrrv's. Suffice to give here a brief explanation of the concept of rrrv and to mention various ways of determining this parameter.

Fig. 2 (a) shows a portion of a typical high voltage network where a power source is feeding a fault which is to be cleared by the circuit-breaker. Assuming a three-phase earth fault this circuit may in the simplest terms and on a single phase basis be reduced to that shown in Fig. 2 (b), where  $L$  is the total inductance of the system limiting the fault current, and  $C$  is the natural capacitance to earth of all the equipment on the side of the circuit-breaker remote from the fault.

The voltage/current relationships in this circuit are shown in Fig. 2 (c). At some stage after the circuit-breaker is signalled to operate, the contacts part forming an arc which lengthens progressively as the contacts continue to move apart. When sufficient distance has been built up between the contacts interruption of the current takes place at, or very near, a natural current zero, at which point, because of the highly inductive nature of the circuit, the voltage of the source  $E$  is practically a maximum. This instantaneous value of voltage, however, does not appear immediately across the circuit-breaker contacts (if it did so breakdown of the gap would surely follow) due to the effect of the capacitance  $C$ , which was initially held discharged by the fault and which now begins to take up a charge. In fact  $L$  and  $C$  form a series resonant circuit with a natural frequency  $f = \frac{1}{2\pi\sqrt{LC}}$  and the

voltage appearing across  $C$ , and hence across the contacts, is of the form shown, the small amount of resistance in the circuit eventually damping this to zero. This high frequency voltage is known as the restriking voltage, or transient recovery voltage, (see Fig 2 (d) which shows the current zero region on an expanded time scale) and for the current interruption which has taken place to be permanent the rate of rise of this voltage must be matched by the rate of rise of the dielectric strength of the medium between the contacts. The rrrv is therefore a measure of the severity of the recovery voltage the system imposes on the circuit-breaker at the instant of interruption.

In practice the restriking voltage will seldom have a single frequency, although it may consist predominantly of a single frequency, but will comprise numerous components differing

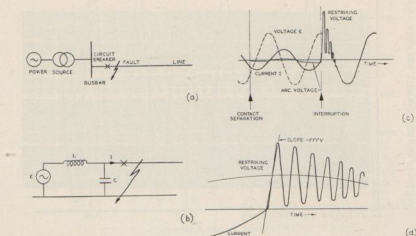


FIGURE 2 INTERRUPTION OF TERMINAL SHORT CIRCUIT IN AC INDUCTIVE CIRCUIT



in magnitude and frequency. To ensure that a circuit-breaker is obtained which is equal to the recovery voltage severity the system will impose under all possible conditions it is therefore apparent that an estimate of the rrrv's the system will produce with a wide variety of circuit connections must be obtained prior to enquiring for the equipment.

Because of the complexity of the calculations involved the most convenient method of determining projected system rrrv's was, until recently, by using a miniature system or transient analyser. Digital computers, however, have now made the calculation of rrrv's a simpler and far more convenient matter, and such a device was used in estimating the recovery voltage conditions in the Commission's initial 400-kV projects. Fig. 3 shows a typical recovery voltage transient obtained during the studies made, while Fig. 4 shows an envelope curve of all the points calculated. The shape of this curve is typical for a high voltage power system.

### 2.(2) Short-line faults

Short line or kilometric faults is the name given to those faults which do not occur at the circuit-breaker terminals as depicted in Fig. 2, but which occur on a line a short distance, up to, say, five miles, from the circuit-breaker. When a short-line fault is interrupted transmission line travelling wave phenomena give rise to a high-frequency, saw-toothed recovery

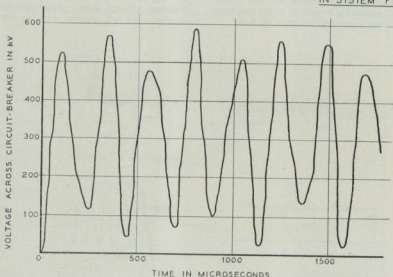


FIGURE 3 RECOVERY VOLTAGE TRANSIENT CALCULATED IN SYSTEM rrrv STUDY

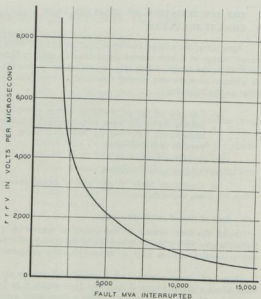


FIGURE 4 ENVELOPE OF POINTS CALCULATED IN SYSTEM rrrv STUDY

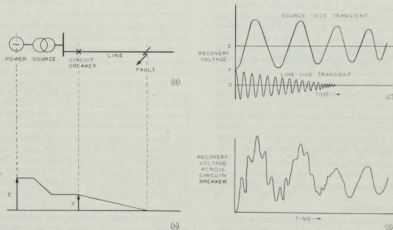
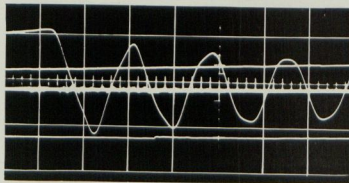


FIGURE 5 SHORT LINE FAULT

voltage component across the circuit-breaker contacts; this component has a very high rate of rise, and since the short circuit volt-amperes are not appreciably reduced, the fault being only a short distance from the circuit-breaker, this high rrrv is coupled with a high short circuit MVA, i.e. referring again to Fig. 4, it imposes a more onerous condition on the circuit-breaker than do normal terminal short circuits.

The fault condition to be considered is shown in Fig. 5 (a). Again, in the highly inductive circuit that exists, the

current will be interrupted by the circuit-breaker at very nearly a natural current zero when the voltage is instantaneously practically a maximum. However, the voltage on the line side of the circuit-breaker is not now zero at this instant, but a finite value equal to the voltage dropped along the line to the point of fault, which is the zero voltage point in this case, Fig 5 (b). After interruption the voltages on each side of the circuit-breaker contacts "recover" independently via damped oscillations, on the source side to the value  $E$  and



FAULT APPROXIMATELY 2 MILES  
FROM CIRCUIT-BREAKER  
FREQUENCY 12 KHZ

FIGURE 6: SHORT LINE FAULT: LINE TRANSIENT

on the line side to zero, Fig. 5 (c); the recovery voltage appearing across the circuit-breaker is the difference of these two independent recovery voltages, Fig. 5 (d). The frequency of the line side component is solely a function of the length of the line between circuit-breaker and fault, the shorter the distance to the fault the higher the frequency. The nearer the fault is to the circuit-breaker, however, the smaller will be the magnitude of the high frequency component. With this situation it is evident that there must be a critical fault point at which the magnitude of the line oscillation, coupled with the relatively high rrrv, will impose the severest stress on the circuit-breaker. This distance varies somewhat for different systems and different circuit-breakers, but typically is about at the 1 kilometre point, hence the name kilometric fault.

Fig. 6 is an actual oscillogram of a high frequency line transient taken during the testing of a circuit-breaker to prove its capability of dealing with short-line faults.

### 2.3) Asynchronous conditions

If under certain, perhaps abnormal, conditions a circuit-breaker is called upon to control a single tie line between two sources of generation, it may be subject to asynchronous conditions should the two systems fall out of synchronism.

Two systems interconnected by a single tie line are shown in Fig. 7 (a). The voltage appearing across the open circuit-breaker after interruption is dependent upon the phase angle between the internal voltages of the two sources at the instant of opening and on the method of earthing the system neutrals. The case giving rise to the highest voltage is when the two systems are 180° out of phase. The magnitude of the recovery voltage may vary in value up to 3E and, for the limit of what

is normally taken to be an effectively earthed system, can amount to approximately 2.6E.

The synchronising current that flows under asynchronous conditions prior to interruption of the circuit-breaker is dependent on the total impedance of the sources and the interconnecting tie. As shown in Fig. 7(a), if ZA and ZB are the total system impedances on either side of the circuit-breaker, then the asynchronous current will vary according to the graph of Fig. 7 (c) for various ratios of ZA/ZB. The highest current flows when ZA = ZB and amounts to 50% of the possible short-circuit current at the circuit-breaker location. This may be seen very simply as follows: if ZA = ZB = Z, say, then the infeed from either source for a fault at the circuit-breaker will be E/Z, and the total short-circuit current will be 2E/Z; the asynchronous current on the other hand will be 2E/2Z = E/Z, i.e. half the short-circuit current. This is an unlikely condition and it is usual to assume that the asynchronous current will be about 25% of the full short-circuit current.

The rrrv under asynchronous conditions is usually comparatively low. The voltage at the circuit-breaker Vb, Fig. 7 (d), differs only slightly from that of the adjacent source Ea and, following interruption of the current, the voltage on the System A side of the circuit-breaker recovers to Ea via a relatively high frequency transient, but with a low amplitude, while the voltage on the System B side recovers with a high amplitude to Eb, but with a low frequency which is heavily damped due to the presence of the line.

Asynchronous conditions must in every case be investigated on their merits in arriving at the correct values of voltage and rrrv to specify.

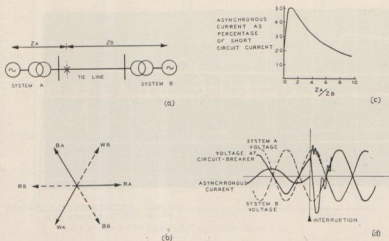


FIGURE 7 ASYNCHRONOUS CONDITIONS

#### 2.4) Switching overvoltages

Apart from coping with short-circuit conditions, aspects of which have been dealt with above, a circuit-breaker must also operate safely during normal switching duties without in any way overstressing the system.

Certain duties naturally give rise to overvoltages in a system following switching; these are

- (a) The de-energising of unloaded transformers
- (b) The de-energising of unloaded transmission lines
- (c) The energising, or re-energising after a short time, of unloaded transmission lines.

The overvoltage that occurs when switching off an unloaded transformer is due to a condition known as current chopping, combined with the fact that the circuit being switched is highly inductive. The magnetising current of the transformer is small, of the order of a few amperes only, and the action of most circuit-breakers on a current of this magnitude is to force an interruption before a natural current zero, i.e. chopping takes place. This results in a high voltage appearing at the circuit-breaker terminals produced by the trapped energy in the transformer inductance, which acts to maintain the current if possible. In most instances re-establishment of the current does take place and the action is then repeated, perhaps many times, as the current reduces, until final extinction is achieved.

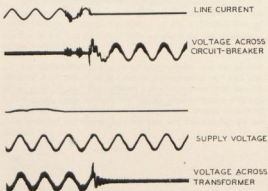


FIGURE 9 DE-ENERGISING UNLOADED  
TRANSFORMER

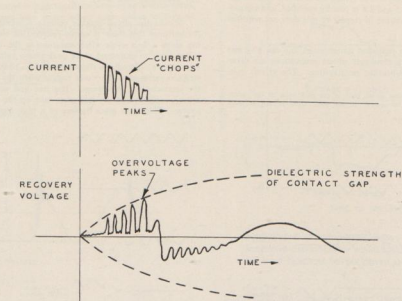


FIGURE 8: SWITCHING OVERVOLTAGES DUE  
TO CURRENT CHOPPING

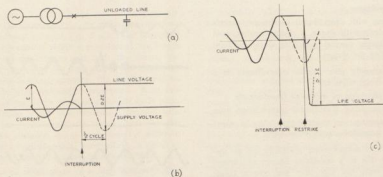


FIGURE 10 SWITCHING OVERVOLTAGES WHEN DE-ENERGISING AN UNLOADED TRANSMISSION LINE

A sketch of an oscillogram showing clearly repeated current chopping is reproduced in Fig. 8; Fig. 9 is an actual oscillogram of this phenomenon.

Although surge diverters are invariably connected to the terminals of high voltage transformers and provide protection against such switching surges, it is nevertheless desirable to limit the overvoltages as far as possible. Depending on the insulation co-ordination of the system a maximum overvoltage factor\* of between 2.5 and 2.8 is usually specified, and guarantees for the circuit-breaker in respect of this duty are required accordingly.

De-energising an unloaded transmission line can give rise to severe switching overvoltages unless precautions are taken to render the circuit-breaker restrike-free. The circuit con-

sidered is shown in Fig. 10 (a); in this condition the transmission line acts very much as a condenser and when the charging current is interrupted at, or very near, a natural current zero, Fig. 10 (b), the circuit in this case being highly capacitive the voltage is again near a maximum in the cycle. The line is then isolated and this peak voltage is trapped on the line. If the interruption of current is permanent there is no danger of serious overvoltages occurring and the line charge will eventually leak away.

Should the circuit-breaker restrike however, and Fig. 10 (b) indicates that there is ample justification for this happening since a half cycle after interruption the contact gap is called upon to withstand twice peak phase voltage, the situation is very different, as illustrated in Fig. 10 (c). Here a restrike is assumed at the worst instant when the voltage across the contacts is a maximum. The line and source are once more connected and the line must take up the voltage of the source. This takes place by way of a high frequency oscillation.

\* Overvoltage factor defined as the ratio of the peak value of the switching transient voltage to neutral, to the peak value of the phase-to-neutral voltage.

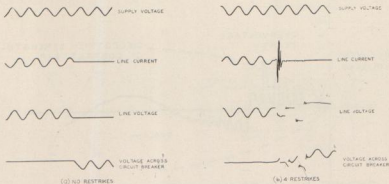


FIGURE 11 TRANSMISSION LINE DE-ENERGISING

tion the frequency of which is determined by the parameters of the source and the line. A corresponding high frequency current flows and if this is assumed to be interrupted at the first zero a voltage now approximately three times peak phase voltage will be trapped on the line. Repeated restrikes in this way can cause progressively higher over-voltages. In practice, however, an overvoltage factor of 3 is rarely exceeded.

Fig. 11 (a) has been drawn from an oscillogram taken during an interruption without restrikes, while Fig. 11(b) shows a drawing from oscillogram of a similar duty having 4 restrikes.

In the specification of HV circuit-breakers for line de-energising duty, details of the line parameters and the length of the line are given and guarantees sought that when switching out such a line the circuit-breaker will not restrike.

Energising unloaded transmission lines can also give rise to high overvoltages, though for an entirely different reason. Assuming for simplicity the line to consist of a lumped capacitance, if the circuit-breaker is closed when the source voltage is an instantaneous maximum, the worst case, then the line will attain this voltage by way of a high frequency transient with a peak value approaching twice peak phase voltage, Fig. 12 (a); in practice of course the line comprises distributed elements and the effect of the line transit time and the nature of the source may cause overvoltages higher in value. The position is further aggravated if high speed auto-reclosing is considered, since re-energising may occur when peak phase voltage of opposite polarity is trapped on the line, Fig. 12 (b).

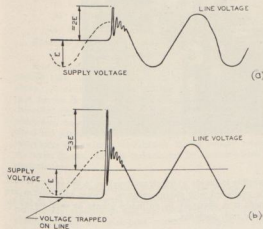


FIGURE 12 TRANSMISSION LINE ENERGISING AND RE-ENERGISING

Unlike the previous switching overvoltages discussed, this type of overvoltage is to a large extent independent of the circuit-breaker, although the timing of the individual phases relative to one another does have an effect on the magnitude of the overvoltages.

Energising and re-energising overvoltages can be greatly reduced, if necessary, by the use of closing resistors. The line is energised through the resistors and a short time later, say 10 milliseconds, these are shorted by the main contacts closing; the line is thereby energised in stages and surges that take place between the source and the line are damped by the resistors.

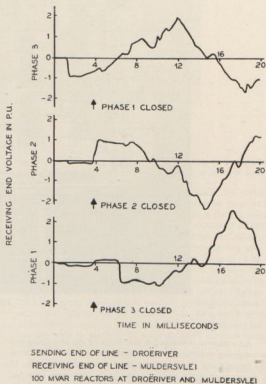


FIGURE 13 ENERGISING OVERVOLTAGES DETERMINED IN SYSTEM SWITCHING STUDY

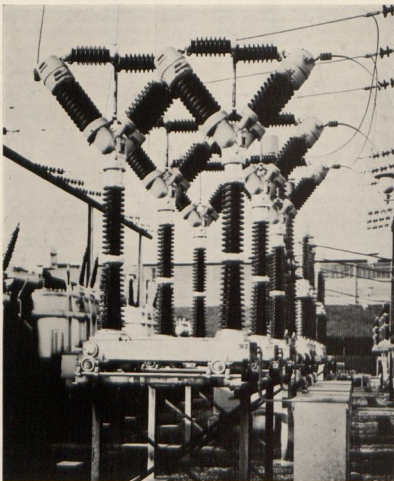


Fig. 14

An extensive investigation was made of the energising and re-energising overvoltages that might arise on the transmission line to the Cape. A digital computer was used and in Fig. 13 is shown plotted the voltage wave-forms that were obtained when the discharged Droërivier — Muldersvlei line was energised from Droërivier; the maximum overvoltage factor resulting was 2.62. Under the same system conditions, but with a trapped charge, when the overvoltages could be expected to be considerably greater, a closing resistor of 400 ohms inserted for 1 cycle (20 milliseconds) reduced the maximum overvoltage factor to 1.82. From the results of the studies it was

possible to decide which circuit-breakers in the system should be purchased with closing resistors. Unless such studies are made it is obviously by no means always an easy matter to make such decisions.

### 3. TYPES OF HIGH-VOLTAGE CIRCUIT-BREAKERS

Having discussed some of the factors to be considered when specifying HV circuit-breakers, what circuit-breakers are available that meet the stringent requirements often demanded? The available types may be classified as follows:-

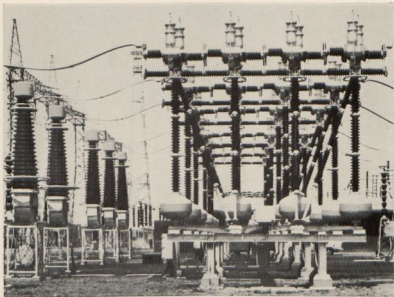


Fig. 15

- (a) Low-oil-volume circuit-breakers
- (b) Air-blast circuit-breakers
- (c) Sulphur hexafluoride (SF<sub>6</sub>) circuit-breakers.

Examples of these are illustrated in Figs. 14, 15 and 16.

Low-oil-volume circuit-breakers have completely supplanted bulk oil circuit-breakers at voltages of 400 kV and above. A number of interrupters are arranged in series, perhaps ten or more per phase, usually in vee formation, and controlled simultaneously from a single operating mechanism which may be pneumatically or spring driven. Grading capacitors and possibly also switched resistors in parallel with each interrupter ensure even distribution of the voltage between the series breaks. Closing resistors can be accommodated on some designs.

Air-blast circuit-breakers are perhaps best known for this class of duty. In modern designs the interrupter contacts are permanently pressurised, and the valve gear controlling the compressed air arc quenching medium is housed at high voltage adjacent to the contacts and is operated pneumatically or by insulated rods connecting to air motors or spring drives at earth potential. Depending on the design grading capacitors and/or resistors are employed. For severe duties involving high rrrv's, to which air-blast circuit-breakers are particularly sensitive, use is frequently made of low ohmic value switch-

ing resistors which have the effect of damping the system transients. Closing resistors can be fitted to most modern designs.

SF<sub>6</sub> Circuit-breakers are a comparatively new development. The operating principles are the same as those of the air-blast type, but the extinguishing medium is the gas sulphur hexafluoride and upon operation it is not exhausted to atmosphere but expanded into a receiving chamber for subsequent compression and re-use. SF<sub>6</sub> is an electro-negative gas, i.e. its molecules have a great affinity for free electrons, with excellent dielectric properties. At atmospheric pressure the dielectric strength of SF<sub>6</sub> is over twice that of air and increases rapidly with pressure; at a pressure of about 1 kg/sq. cm (14.2 psi) gauge the dielectric strength is over three times that of air and approaches the value for oil. As a result of these outstanding properties of the gas, SF<sub>6</sub> circuit-breakers are invariably able to perform the same duties as air-blast breakers with fewer interrupters.

The aim with all HV circuit-breakers is naturally to interrupt fault currents in the shortest possible times. In this way system stability is improved and fault damage kept to a minimum. It is incredible to think that, despite the size and complexity of modern HV circuit-breakers, total interrupting times, measured from the instant of energisation of the trip coils to final arc extinction in all phases, of three cycles (0.06 seconds) and less are commonly achieved.



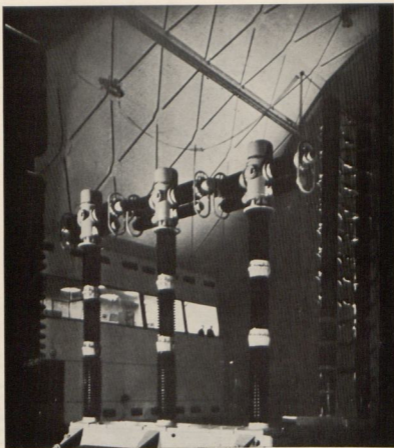


Fig. 16

#### 4. CIRCUIT-BREAKERS FOR THE COMMISSION'S 400-KV NETWORK

The first 400-kV yard to be energised in South Africa was made alive at Camden power station at the beginning of September, 1966. Fig. 17 is a photograph of the 22,500 MVA, air-blast circuit-breakers installed at this site. Of British manufacture, these have twelve series interrupters per phase and incorporate integral sequential series isolators; with this type of design once the interrupters have cleared the circuit the isolators open sequentially, whereupon the interrupters return to the closed position; the circuit is remade using the high-speed isolators only.

The 400-kV yard at Atlas was energised in March of this year (1967). The circuit-breakers there are also of British manufacture, Fig. 18. These are of the permanently pressurised,

air-blast type rated 17,500 MVA, with six series interrupters per phase.

The circuit-breakers on order for Perseus, rated 17,500 MVA, are of French design, similar to those shown in Fig. 19, and, like the circuit-breakers at Atlas, are permanently pressurised and have six series interrupters per phase. To reduce high switching overvoltages that system studies showed might occur when energising the north-going lines at this station, these line circuit-breakers are to be fitted with closing resistors.

For Hydra, 17,500 - MVA, multibreak, low-oil-volume circuit-breakers are on order, Fig. 20. Of Swiss make these have ten series interrupters per phase. Each phase has a separate spring closing mechanism, and, to ensure positive three-phase operation, mechanical as well as electrical interlocking between the mechanisms is provided.

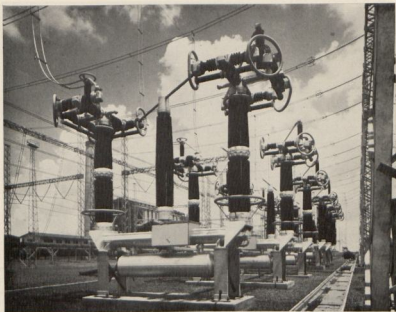


Fig. 17

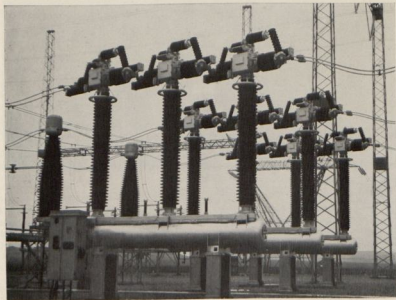


Fig. 18

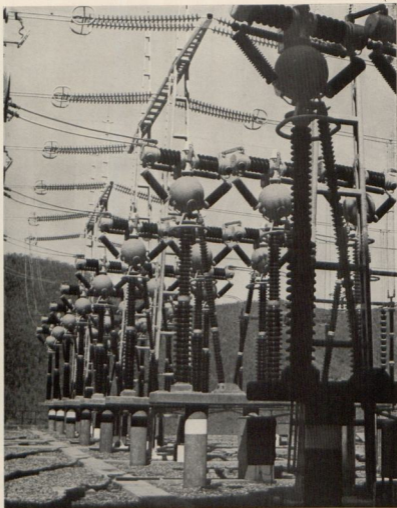


Fig. 19

17,500-MVA, six-break, permanently-pressurised, air-blast circuit-breakers of French manufacture are to be installed at Droërivier and Muldersvlei, Fig 21. It is deemed necessary on the circuit-breakers controlling the long lines between these substations to fit closing resistors, and a close-up view of the interrupter arrangement showing the closing resistors in position is reproduced in Fig 22.

The circuit-breakers for Grootvlei power station (1200 MW, now under construction some 25 miles from Atlas) and

Hendrina power station are to be similar to the Droërivier and Muldersvlei units, but will have higher ratings, 22,500 MVA at Grootvlei and 30,000 MVA at Hendrina, Fig. 23. The circuit-breakers on the south-going lines out of Grootvlei are to have closing resistors.

##### 5. CONCLUSION

It is hoped that the aspects touched upon in the paper involving the specification of high voltage circuit-breakers, aspects which are by no means new but with which the user

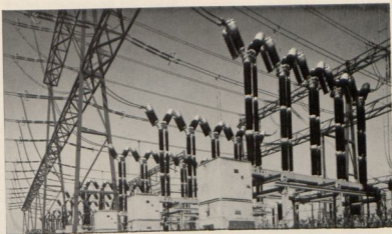


Fig. 20

of lower voltage circuit-breakers is perhaps not so familiar, coupled with a brief look at some of the circuit-breakers going into service in the national 400-kV transmission system, will have proved of interest.

The permission of the Electricity Supply Commission to publish this paper is gratefully acknowledged.

**HOOGSPANNING-STROOMBREKERS SOOS GEBRUIK OP DIE NATIONALE 400 KV. TRANSMISSIESTELSEL.**  
D. R. DUFFIELD, B.Sc. (ir.)

Reeds in 1963 is besluit om die spanning van 400 KV. te gebruik tussen die nuwe EVKOM kragcentrales in Oos-Transvaal en die vragpunte van die Witwatersrand en later die Kaap en Natal. Vyf substasies word beplan op die 900 myl tussen die Transvaal en die Kaap. Die referaat handel oor die spesifikasie en die keuse van die stroombrekers vir die nasionale 400 KV. transmissiestelsel.

Afgesien van spanning, maksimum vrag en kortsluitingswaardes — almal faktore wat deur die transmissiestelsel bepaal word — moet ander vereistes soos

- (a) spoed van heropbou van die herwinning-spanning;
- (b) kortlynfoute;
- (c) Asinchrone toestande;
- (d) toestande wat aanleiding kan gee tot oorspanning wanneer geskakel word

ook ondersoek word.

Die skrywer behandel dan agtereenvolgens besonderhede van die probleme en hoe dit met behulp van 'n elektroniese rekenaar opgelos is. Die apparaat het dit moontlik gemaak om deeglik op die regte keuse van stroombrekers in te gaan.

Die skrywer behandel ook die drie tipes van stroombrekers beskikbaar vir 'n spanning van 400 KV. en wys op die verskillende soorte wat vir gebruik op die lyn gekies is.



Fig. 21

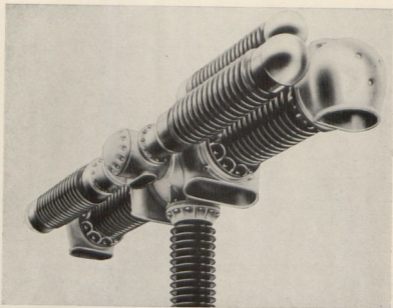


Fig. 22

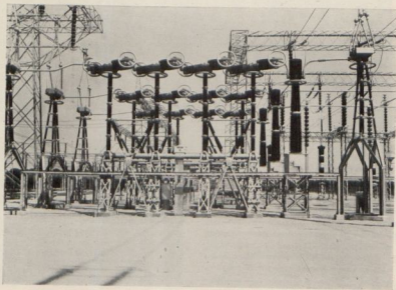


Fig. 23

## INSTANT WATER HEATERS AND THE POWER SUPPLY AUTHORITY

Features for discussion:-

1. In order to improve load factor and conserve capital expenditure the policy trend all over the world in regard to electric heating is to minimise ampere demand and spread the load over time, i.e. the "storage principle". Conventional water heating practise fulfills this.
2. The commercial gimmick "Instant" has now spread to various water heaters in direct conflict with the foregoing policy.  
These units characteristically are direct-connected to water tap outlets, are switched by water flow and heat either by "calrod-type" elements or direct water conduction. Because of the short-time contact between water and heating element the ampere-demand is high and of short duration. They vary in size between 3 KW single phase (13 amp.) to above 20 KW three phase (30 amp.).
3. Thermal type demand meters normally have about thirty minutes time lag in line with overload ratings of most electrical equipment. The demand of an "Instant" water heater would only register about 30% of its demand for a three or four minute draw-off and it constitutes a "demand-evading" appliance.

The effects of this meter-evasion for widespread separately metered instant-heater installations can be serious because failure to collect the proper demand charge at times of area peak load fails to amortise capital invested in the requisite supply mains and substations. It would be less serious for a large scale installation in a bulk-metered building because of diversity within this single gross load.

4. The overload gradings of fuses or circuit-breakers are likely to be completely upset by installations of instant water heaters in existing installations.
5. After years of struggle with "the six feet rule" these units involve electrical connections right at the water taps, in turn involving extreme moisture-proofing and earthing precautions.

Especially where plastic construction is adopted, it is inevitable that units on a tap outlet are more prone to damage than most other electrical appliances and it is well-known how remiss users can be in having damage repaired. It is possible that wide-scale adoption of these units can introduce more hazards to the use of electricity.

## BLITS-WATERVERWARMERS EN DIE KRAGVERSKAFFINGSOWERHEID

Eienskappe vir bespreking:-

1. Teneinde die lasfaktor te verbeter en kapitale uitgawe te konserveer, is die beleidsrigting in verband met verhitting by wyse van elektrisiteit oral in die wêreld om die ampere-aanvraag sover moontlik te beperk en om die las oor 'n tydperk te versprei, d.w.s. die beginsel van "opberging". Die konvensionele metodes van waterverhitting voldoen aan hierdie beleid.
2. Die "blits"-begrip in die handel het nou ook na verskillende soorte waterverwarmers uitgebrei, wat direk in stryd is met die voornoemde beleid.  
'n Kenmerk van hierdie eenhede is dat hulle direk aan waterkraan verbind word, dat hulle deur die vloei van die water aangeskakel word en dat hulle die water by wyse van "calrod"-tipe elemente of deur direkte hittegeleiding déúr die water verhit. Weens die kort tyd wat die water met die verhittingselement in aanraking kom, is die ampere-aanvraag hoog en van korte duur. Die verwarmers wissel in grootte van 3 kw enkelfase (13 ampere) tot meer as 20 kw drie-fase (30 ampere).
3. Aanvraagmeters van die termiese tipe het gewoonlik 'n tydsvertraging van omtrent dertig minute in lyn met die oorbelastingvermoë van die meeste elektriese toerusting. Die aanvraag van 'n "blits"-waterverwarmer sal slegs sowat 30% van sy totale aanvraag ten opsigte van 'n kragafvoering van drie of vier minute op die meter registreer, en dit is dus in wese 'n aanvraag-ontduikende toestel.

In die geval van wydverspreide apart-gemeterde blitsverwarmerinstallasies kan hierdie vorm van meterontduiking ernstige gevolge hê, aangesien dit, in gevalle waar dit nie moontlik is om die gepaste aanvraaggelde ten tye van spitsbelasting in sekere gebiede te in nie, ook nie moontlik is om die amortisasie van die kapitaal wat in die benodigde hoof-toevoerlyne en substasies belê is, te dek nie. In die geval van 'n grootskaalse installasie in 'n gebou wat met 'n grootmaatmeter toegerus is, sal die gevolge nie so ernstig wees nie, weens individuele skommeling binne die omvang van die massale belasting.

4. Die installering van blits-waterverwarmers in bestaande installasies kan tot gevolg hê dat die oorbelastinggradering van sekerings, of van stroombrekers, omvergewerp word.
5. Nadat daar jare lank met die "ses-voet-reël" geworstel is, bring hierdie eenhede elektriese aansluitings vlakby die waterkraan mee, wat op hul beurt weer die uiterste voorsorg met betrekking tot vogvering en aarding nodig maak. Veral waar daar van plastiek-konstruksie gebruik gemaak word, is dit onvermydelik dat eenhede wat aan 'n waterkraan geïnstalleer is, makliker beskadig sal raak as ander elektriese toestelle, en dit is welbekend hoe traag verbruikers soms kan wees om sulke skade te laat herstel. Dit is dus moontlik dat die grootskaalse aanvaarding van hierdie eenhede die gebruik van elektrisiteit al hoe meer gevaarlik kan maak.

6. Although certain brands of these heaters have been "found suitable for use" by the Recommendations Committee for new electrical commodities, that Committee is not called upon to comment upon the prospective effects of their large scale and indiscriminate introduction.
7. Johannesburg has offered some manufacturers their co-operation in field tests of installations in selected large buildings without response. It is not permitting installation until the end results of large scale adoption become clear.
8. It is well-known that electric radiators for space-heating are highly uneconomic for the supply authority because they inevitably coincide with monthly peak demand and are in use for only the four winter months.

An assessment as to whether instant water heaters have worse or better characteristics than radiators has yet to be made.

It is characteristic of such heaters that their times of usage largely coincide with the day peak loads of a power system.

9. Appended is some relevant information covering:-
  - (a) Response to circular covering installation of these heaters in other municipalities.
  - (b) Recovery times of conventional storage heaters.
  - (c) Comparative costs between conventional storage and "instant" heaters.
  - (d) Relative time factors.
  - (e) Registration curve of thermal demand meter.
  - (f) Details of known types of instant heaters.

#### COMMENT

The purpose of this submission is to evoke discussion on the desirability or otherwise of permitting an "instant demand short-duration" appliance of this nature.

17th March, 1967.

R. LEISHMAN.

#### 1. SUMMARY OF REPLIES FROM MUNICIPALITIES INSTANT WATER HEATERS

##### CAPE TOWN

10 installed. Type of consumer not stated. Normal tariffs.

No load limiting or interlocking.

20/30 kW 3 units acceptable.

No large buildings equipped.

No information on diversity, load factor, complaints, effect on mains, etc.

6. Alhoewel sekere soorte van hierdie verwarmers deur die Komitee vir Aanbevelings insake Nuwe Elektriese Ware as "geskik vir gebruik" bevind is, is dit nie die taak van daardie Komitee om kommentaar te lewer omtrent die moontlike uitwerking van die grootskaalse en onoordeelkundige invoering van hierdie soort warmer nie.
7. Johannesburg het aan sekere vervaardigers hul samewerking met betrekking tot gebruikstoets van installasies in sekere uitgesoekte geboue gebied, dog sonder enige reaksie. In hierdie stad word die installasie van hierdie verwarmers nie toegelaat tot tyd en wyl die finale uitslae van grootskaalse aanvaarding daarvan elders bekend is nie.
8. Dit is 'n welbekende feit dat elektriese uitstraalverwarmers wat vir ruimteverwarming gebruik word, hoogs onekonomiese vir die voorsieningsowerheid is omdat hul gebruik onvermydelik met die maandelikse spits-aanvraag saamval en hulle slegs gedurende die vier wintermaande gebruik word.  
Daar is nog nie bepaal of die eienskappe van blits-waterverwarmers beter of slegter as dié van ruimteverwarmers is nie.  
Dit is 'n eienskap van hierdie soort verwarmers dat hul gebruikstye gewoonlik met die tydspeke van spitsbelasting van 'n elektriese kragstelsel gedurende die dag saamval.
9. Hier volg nou sekere tersaaklike inligting, wat die volgende omvat:-
  - (a) Die reaksie op 'n omskrywe in verband met die instalasie van hierdie verwarmers in ander munisipaliteite.
  - (b) Die hersteltydspeke van konvensionele warmte-akkumulatort.
  - (c) Vergelykende koste van konvensionele warmte-akkumulatort en blitsverwarmers.
  - (d) Relatiewe tydsfaktore.
  - (e) Registrasiekurwe van termiese aanvragmeter.
  - (f) Besonderhede van bekende soorte blitsverwarmers.

#### KOMMENTAAR

Die doel van hierdie voorlegging is om bespreking uit te lok omtrent die wenslikheid, aldan nie, van die toelating van toestelle soos hierdie, wat 'n hoë onmiddellike aanvraag oor 'n kort tydperk het.

17 Maart 1967.

R. LEISHMAN.

#### 1. OPSOMMING VAN ANTWOORDE VAN MUNISIPALITEITE ONTVANG INSAKE BLITS-WATERVERWARMERS

##### KAAPSTAD

10 geinstaleer. Tipe verbruikers nie aangedui nie. Normale tariewe. Geen grendeling of beperking op belasting nie. Driefasige eenhede van 20/30 kW aanvaarbaar. Geen groot geboue toegerus nie.

Geen inligting aangaande interne skommeling, lasfaktor, klages, uitwerking op hoofgeleidings ens., nie.

## DURBAN

About 100 installed. All dentists/doctors/hairdressers. Normal tariffs.  
Load limiters for units above 6.6 kW single phase. (30 amps).  
No details of load limits.  
Not in favour of 20/30 kW 3 units.  
No large buildings equipped.  
No information on diversity, load factor, complaints, effects on mains, etc.

## PORT ELIZABETH

16 installed. All domestic. Normal tariffs.  
No load limiting or interlocking except that not in favour of 20/30 kW 3 units.  
No large buildings equipped.  
No information on diversity, load factor, etc.

## BLOEMFONTEIN and KIMBERLEY

No heaters installed.  
No information or comments.

## 2. RECOVERY PERIODS FOR STANDARD STORAGE WATER HEATERS

60°F to 160°F

Capacity Galls.	Load kW	Time	
		Hrs.	Mins.
3	1.0	0	55
5	1.5	1	03
10	1.5	2	03
20	2.0	3	04
30	3.0	3	06
40	4.0	3	04
60	6.0	3	05

## 3. COMPARATIVE COSTS: STORAGE AND INSTANT

Storage Heaters		Instant Heaters	
Without Supply Tank/Valve			
3 gall.	— R39	Sinks or handbasins	
5 gall.	— R43.50	7 kW Instahot	R74.50
10 gall.	— R48	Handbasin and bath	
20 gall.	— R63	in close proximity—	
30 gall.	— R69	10 kW Instahot	R79.00
40 gall.	— R90	For large homes,	
60 gall.	— R129	factories, etc. requiring	
30 gall. Comb.	— R93	more than 2½	
40 gall. Comb.	— R105	galls. minute, 20kW	R120
		The Mini-geyser designed	
		for a sink or handbasin rated at	
		3 kW	R22.50

40 Gall. G.I. Header Tank for all sizes	— R 5
40 Gall. Polythene Header Tank for all sizes	— R 9
Larson Tank for all sizes	— R15
Latco Valve for all sizes	— R 8.40

## DURBAN

Ongeveer 100 geïnstalleer. Almal tandartse, dokters, haarkappers.  
Normale tariewe. Lasbeperkers vir eenhede bokant 6.6 kW enkelfase (30 ampere). Geen besonderhede van belastingsbeperkings.  
Nie ten gunste van driefasige eenhede van 20/30 kw. nie.  
Geen groot geboue toegerus nie.  
Geen inligting aangaande interne skommelinge, lasfaktor, klages, uitwerking op hoofgeleidings ens., nie.

## PORT ELIZABETH

16 geïnstalleer. Almal huishoudelik. Normale tariewe.  
Geen grensdeling of beperking op belasting nie, dog nie ten gunste van driefasige eenhede van 20/30 kw. nie.  
Geen groot geboue toegerus nie.  
Geen inligting aangaande interne skommelinge, lasfaktor ens., nie.

## BLOEMFONTEIN EN KIMBERLEY

Geen verwarmers geïnstalleer nie. Geen inligting of kommentaar nie.

## 2. HERSTELTYDPERKE VIR STANDAARD WARMTE-AKKUMULATORS

60°F tot 160°F

Vermoë in gellings	Las in kw	Tyd	
		Ure	Minute
3	1.0	0	55
5	1.5	1	03
10	1.5	2	03
20	2.0	3	04
30	3.0	3	06
40	4.0	3	04
60	6.0	3	05

## 3. VERGELYKENDE KOSTE: WARMTE-AKKUMULATORS EN BLITSVERWARMERS

Warmte-akkumulators		Blitsverwarmers	
Sonder Voorraadtenk/klep			
3 gell.	— R39	Opwasbakke en	
5 gell.	— R43.50	handewasbakke.	7
10 gell.	— R48	kw Instahot	— R74.50
20 gell.	— R63	Handewasbak en bad	
30 gell.	— R69	naby mekaar. 10 kw	
40 gell.	— R90	Instahot	— R79
60 gell.	— R129	Vir groter huise, fabriek- rieke, ens., wat meer	
30 gell. kombinasie	R93	as 2½ gell. per minuut	
40 gell. kombinasie	R105	nodig het. 20 kw	R120
		Die mini-verwarmer, ontwerp vir 'n opwasbak	
		van 3 kw	— R22.50

40 gelling gegalvaniseerde tenk vir alle groottes	— R 5
40 gelling politeentenk vir alle groottes	— R 9
Larson-tenk vir alle groottes	— R15
Latco-klep vir alle groottes	— R 8.40



#### 4. TIME FACTORS

##### Handbasin:

1½ galls. 60°F to 120°F. 7 kW Instahot heater Btu's required 1½.10.60 = 900

$$\therefore \text{takes } \frac{900}{3410 \times 7} = .0378 \text{ hrs. i.e. } \mathbf{2.26 \text{ mins.}}$$

##### Bath:

20 galls. 60°F to 100°F. 10 kW Instahot heater Btu's required 20.10.40 = 8,000

$$\therefore \text{takes } \frac{8,000}{3410 \times 10} = 0.234 \text{ hrs. i.e. } \mathbf{14 \text{ mins.}}$$

##### Handbasin:

1½ galls. 60°F to 120°F. 3 kW Mini-geyser

$$\text{Time} = \frac{900}{3410 \times 3} = 0.088 \text{ hrs. i.e. } \mathbf{5.3 \text{ mins.}}$$

30 gall. 3 kW

Storage 1 Bath 9 galls. @ 160°F  
11 galls. @ 60°F

Recovery period 53 mins.

#### 4. TYDFAKTORER

##### Handwaskbak:

1½ gellings 60°F tot 120°F 7 kw Instahot-verwarmer BTE benodig 1½.10.60 = 900

$$\therefore \text{neem dit } \frac{900}{3410 \times 7} = .0378 \text{ ure, d.i. } \mathbf{2.26 \text{ m.}}$$

##### Bad:

20 gellings 60°F tot 100°F 10 kw Instahot-verwarmer BTE benodig 20.10.40 = 8,000

$$\therefore \text{neem dit } \frac{8,000}{3410 \times 10} = 0.234 \text{ ure, d.i. } \mathbf{14 \text{ m.}}$$

##### Handwaskbak:

1½ gellings 60°F tot 120°F 3 kw Miniverwarmer

$$\text{Tyd: } \frac{900}{3410 \times 3} = 0.088 \text{ ure, d.i. } \mathbf{5.3 \text{ m.}}$$

30 gelling 3 kw

Akkumulator

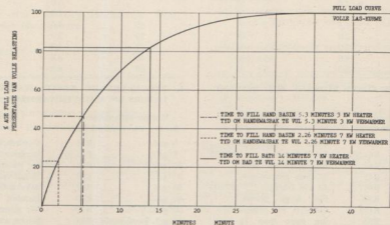
1 Bad 9 gellings @ 160°F

11 gellings @ 60°F

Herstelydperk 53 minute.

CURVE OF LINCOLN-SARGENT 3 PHASE EM MAX DEMAND METER

FERRE VAN LINCOLN-SARGENT EM. NAEST NEM-LANSLAAGTER



**INSTANT WATER HEATERS**

Make	Origin	Dealt with	Passed S.A.B.S. Safety Spec.	Passed by the Recommendations Committee for new Electrical Commodities	Design	Accepted by
Clage	Germany	1961/62	Yes	No—not submitted	3 and 4 kW Single phase element in direct contact with water	Durban
Ajax	Japan	1964	Yes	Yes — subject to: (a) Heater is designed for metal conduit connection (b) Installed in accordance with standard wiring regulations	3 kW Single phase element in direct contact with water	Nil
Allflow	United Kingdom	1965	No—not submitted	No — not submitted	1 and 3 kW Single phase. No other details available	Nil
Instahot	Cape Town	1967	Yes	Yes — subject to: (a) Wired on separate circuit (b) Fitted with adjacent isolator	5 models ranging from 6 kW to 7.8 kW Single phase 11 models ranging from 6 kW to 23 kW Three phase element: Sheathed tubular	Durban Port Elizabeth Cape Town National Housing E.S.C. Cape Western (Single phase only — no application yet for three phase)

**DISADVANTAGES:**

1. No heat storage.
2. Ratio of kW demand/kWh outstandingly high.
3. Peak/average demand could be high causing increase of conductor sizes in supply mains and service connections.
4. Evade true kW demand reading with thermal type meters.

**OUR APPROACH** (at present)

Applicants invited to install limited quantity in selected buildings for field trials as guide to future policy.

**BLITS-WATERVERWARMERS**

Fabriek	Oorsprong	Behandel	Voldoen aan S.A.B.S. se Veiligheids-spesifikasie	Goedgekeur deur Komitee vir Aanbevelings insake Nuwe Elektriese Ware	Ontwerp	Aanvaar deur
Clage	Duitsland	1961/62	Ja	Nee — nie voorgelê nie	3 en 4 K.W. Enkelfase-element in direkte aansaking met water	Durban
Ajax	Japan	1964	Ja	Ja — mits: (a) Verwarmer ontwerp is vir lelypybedrading (b) Verwarmer ooreenkomstig Standaard-bedrading-regulasies geïnstalleer word	3 K.W. enkelfase-element in direkte aansaking met water	Geen
Allflow	Verenigde Koninkryk	1965	Nee—nie voorgelê nie	Nee — nie voorgelê nie	1 en 3 K.W. enkelfase. Geen ander besonderhede beskikbaar nie.	Geen
Instahot	Kaapstad	1967	Ja	Ja mits: (a) Verwarmer op aparte stroombaan bedraad is (b) Verwarmer met aanliggende isolator toegerus is	5 modelle wat wissel van 6 K.W. tot 7.8 K.W. enkelfase — 11 modelle wat wissel van 6 K.W. tot 23 K.W. driefasige-elemente Buisvormig omhul	Durban Port Elizabeth Kaapstad Nasionale Behuising EVKOM Wes-Kaap (Stigs enkelfase — nog geen aansoek om driefase nie)

**NADELE:**

1. Geen hitte-akkumulasie nie.
2. Verhouding tussen K.W. aanvaag en K.W.-ure besonder hoog.
3. Spits/gemiddelde aanvaag kan hoog wees, wat hoër geleiergroottes in hooftoevoerlyne en dienskonneksies kan veroorsaak.
4. Ondaalke ware K.W.-aanvaaglesings met termiese tipe meters.

**ONS BENADERING** (huidig)

Applikante word versoek om beperkte hoeveelheid in uitgesoekte geboue te installeer vir gebruikstoets ten einde toekomstige te kan bepaal.

# NAVORSINGS IN ELEKTRIESE KRAGINGENIEURSWESE EN VERWANTE RIGTINGS IN DIE W.N.N.R.

deur R.B. ANDERSON\* en J. D. N. VAN WYK\*\*



Fig. 1. Die W.N.N.R.-terrein by Scientia buite Pretoria.

## INLEIDING

Die Wetenskaplike en Nywerheidsnavorsingsraad is in Oktober 1945 gestig. Die werksaamhede van die Raad word in 13 Institute voortgesit, 9 waarvan saamgegroeper is op 'n terrein van 374 akkers (sien Fig. 1) naby Pretoria. Drie van die Raad se laboratoria is in Johannesburg en een in Port Elizabeth. Die totale personeel van die Raad is ongeveer 2,500 waarvan tussen 700 en 800 gegradueerdes is. Die begroting van die Raad beloop tans ongeveer R15½-miljoen per jaar.

Die laboratoria van die Wetenskaplike en Nywerheidsnavorsingsraad dek 'n verskeidenheid van dissiplines (sien Fig. 2). Laboratoria soos die Nasionale Fisiese Navorsingslaboratorium, die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe, die Nasionale Chemiese Navorsingslaboratorium, ens., wat dissipline-georiënteerd is en laboratoria soos die Nasionale Bounavorsingsinstituut, die Nasionale Instituut vir Waternavorsing, die Nasionale Instituut vir Padnavorsing, ens., wat probleem-georiënteerd institute is.

Navorsing op die gebied van elektriese ingenieurswese word in meerdere of mindere mate in drie institute van die Wetenskaplike en Nywerheidsnavorsingsraad onderneem, naam-

lik in die Navorsingsdepartement Elektriese Ingenieurswese van die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe wat vyf afdelings, naamlik Outomatisasie, Elektronika van die Vaste Toestand, Toegepaste Elektronika, Elektroniese Instrumentasie en Elektriese Kragingenieurswese behels; die Nasionale Navorsingsinstituut vir Telekommunikasie in Johannesburg en die Afdeling vir Noukeurige Meting van die Nasionale Fisiese Navorsingslaboratorium wat die statutêre verpligting in verband met fundamentele standaarde vir die Republiek dra en wat ook die fundamentele elektriese standaarde in stand hou.

In hierdie referaat sal hoofsaaklik klem gelê word op die werk van die Afdeling Elektriese Kragingenieurswese van die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe, maar daar sal ook verwys word na voorbeelde van werk in die res van die Wetenskaplike en Nywerheidsnavorsingsraad wat

\* Hoof, Afdeling Elektriese Kragingenieurswese.

\*\* Assistent-Direkteur, Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe, verantwoordelik vir Elektriese Ingenieurswese. (Die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe maak voorsiening vir navorsing op beide Wiskunde en Elektriese Ingenieurswese.)



Fig. 2. Skenmatiese voorstelling van W.N.N.R.-organisasie.

van direkte belang in kragingenieurswese is, asook navorsing wat van bykomende belang vir elektriese ingenieurs werksaam in plaaslike owerhede mag wees. Dit moet beklemtoon word dat die werk wat hier beskryf word by wyse van illustrasie gekies is en geen poging aangewend is om alle werk van belang vir kragingenieurswese te dek nie; verder word alleen 'n klein gedeelte van die werk wat op elektriese ingenieurswese in die algemeen gedoen word, of van belang vir elektriese ingenieurs is, gedek.

## ELEKTRIESE KRAGINGENIERSWESE

### 1. Weerlig

#### (a) Weerligtellings

Die elektriese kragnywerheid funksioneer reeds jare suksesvol ten spyte van die aanslae en beskadiging deur weerlig en is daar geleidelik beskermingsmaatreëls ontwikkel om aan besondere behoeftes te voorsien. Nogtans is daar geen betroubare standaard wat gebruik kan word om die doeltreffendheid van dié maatreëls teen weerlig te meet nie. Die sogenaamde „donderstorm-dag” wat gebruik word in die aanduiding van die hewigheid van weerlig, is nie bevredigend nie, veral wanneer omstandighede in verskillende dele van die wêreld vergelyk moet word. Dit is byvoorbeeld bekend dat die verhouding tussen die aantal weerligstrale binne 'n wolk en dié van wolk-tot-grond kleiner in die gematigde streke as in die trope is, ofskoon die rede hiervoor nie bekend is nie. Aan die ander kant vermeerder die gemiddelde aantal weerligstrale per „donderstorm-dag” soos die aantal „donderstorm-dae” per jaar vermeerder, en het in die trope weens die hoër frekwensie van voorkoms van donderstorms, tot gevolg dat die verhouding hierbo genoem tot 'n mate kompenseer word.

Met die voortdurende toename in digtheid en kompleksiteit van geïntegreerde kragtoevoersisteme, soos veral die geval

vandag in Europa is, word dit steeds meer noodsaaklik om die werkverrigting van transmissie — en distribusiestelsels te kan bepaal, en moet die waarskynlikheid van onderbrekings van die kragtoevoer voorspel kan word. 'n Uitgangspunt vir hierdie voorspelling vereis ondermeer 'n kennis van die gemiddelde frekwensie van wolk-tot-grond weerligontladings per eenheidsoppervlakte met inagneming van seisoensvariasies.

Die belangstelling in wolk-tot-grond-weerligtellings het dus gedurende die afgelope aantal jare toegeneem, en 'n internasionale groep van navorsers, wat 'n besondere studie hiervan maak, (1) (CIGRE-komitee Nr. 8, vir weerlig en stuspannings) kom jaarliks bymekaar vir raadpleging en bespreking. Teenswoordig word twee weerligtellings aktief deur die komitee oorweeg. Die stroombaan van die eerste, nl. die CIGRE-LFC-teller Nr. 3, word in Fig. 3 getoon. Die stroombaan is ontwerp om die aantal elektrostatiese veldsterkteveranderings as gevolg van weerlig-ontladings en wat 5V/m oorskry, te tel. Die stroombaan bevat 'n filter wat op 500 Hz afgestem is en wat bedoel is om te verseker dat slegs wolk-tot-grond-ontladings getel word. Die dekkingsradius van die teller word as ongeveer 17 km aanvaar, maar hierdie bereik moet nog bevestig word. Die teller is baie eenvoudig en van stewige konstruksie; dit is goedkoop om te vervaardig en kan deur betreklik ongeskoolde personeel bedien word. Daar is eger aanduidings dat dié teller 'n onbekende persentasie binnewolkse weerligontladings tel.

Heelwat aandag word ook aan die Malan-teller gegee weens die verwagting dat dit slegs wolk-tot-grond-ontladings sal tel. Die beginsel waarop hierdie teller berus, is deur prof. D. J. Malan (2,3) van die Bernard Price-Instituut in Johannesburg ontdek, nl. dat by weerligontladings binne 'n wolk die uitrustings by 5 kHz en 100 kHz omtrent dieselfde intensiteit het, terwyl in die geval van ontladings van wolk-tot-



'n Prototipe-waarnemingstasie op die Wetenskaplike en Nywerheidsnavorsingsraad-terrein by Pretoria word op Fig. 5 getoon en wys die rangskikking van die verskillende antennas,



Fig. 5. (a) Prototipe Rigtingsbepalingstasie (Pretoria).

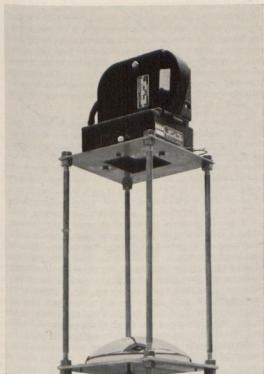


Fig. 5. (b) Fotografiese opstelling vir die fotografiering van weerlig oor effensmeer as 'n hemisfeer.

die rigtingsbepalingstoerusting, die tellers en die ossilloskoop wat gebruik word om die golfvorms, waarvolgens die tipe ont-lading bepaal kan word, te registreer. Fotos geneem deur 'n kamera met 'n dekking van ietwat meer as 'n hemisfeer word gebruik om die rigtingsbepalingstoerusting te kalibreer en om dié tipe en omvang van ontladings te kontroleer.

Na verwagting sal volledige waarnemings gedurende die eerskomende weerligseisoen onderneem word, en die ontleding van die resultate sal hopelik meer inligting oor die werkverrigting van die verskillende tellers lever. Besonderhede oor die finale ontwerp, bou en werking van die teller sal dan aan belangstellendes beskikbaar gemaak word met die hoop dat so veel tellers as moontlik in die Republiek in gebruik geneem sal word. Die Wetenskaplike en Nywerheidsnavorsingsraad

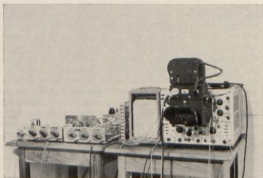


Fig. 5. (c) Ossilloskoop met kamera, gebeurtenisregistreerder, twee tellers en klankversterker vir waarneming van donderstae.

kan dan as koördinerende liggaam optree om die gegewens te versamel en te ontleed om sodoende die weerliggrondontladingsdigtheid vir Suid-Afrika te karteer.

#### (b) Weerligbeskerming

'n Interessante projek is onderneem om 'n kontrakteur te adviseer oor geskikte weerligbeskerming vir 'n hoofwaterpyp



Fig. 5. (d) Rigtingsbepalingstoerusting met ossilloskoop en twee kameras.

tussen Riverdale en Johannesburg (5). Die pyplyn strek oor 'n afstand van 28 myl en het 'n deursnee wat wissel van 84 tot 60 duim. Dat beskerming wenslik is blyk uit 'n geval 'n aantal jare gelede toe lasplekke oor ongeveer 2,000 voet van 'n 18-duim waterpyp tussen Pretoria en Sterkfontein ernstig deur weerlig beskdig is. (6)

Teoreties word vir optimale beskerming vereis dat die induktansie van enige sisteem van beskermende drade so laag as moontlik moet wees terwyl die pype self 'n groot weerstand moet hê; hierdie weerstand is hoofsaaklik te wyte aan die neopreen-rubberverbindings tussen die pylplengtes. Gedurende 'n ontleding sal 'n gedeelte van die weerligstroom deur die grond in die onmiddellike omgewing van die pyp vloei. Die verdeling van die stroom tussen die grond en die pyp is moeilik om te voorspel weens die groot variasies in grondweerstand oor betreklik kort afstande. Na ondersoek is aanbeveel dat vyf beskermende drade geïnstalleer moet word; drie bo, en twee onder die pyp. Die drade word op gelyke afstande met mekaar verbind. Daar word verwag dat hierdie maaatreëls in gebiede waar die grond 'n redelik lae weerstand het, voldoende beskerming sal bied. Waar die pyproete oor vaste rots gaan sal die grondgeleiding na verwagting geen belangrike rol speel nie en is daar 'n wesenlike gevaar dat die pyp beskdig sal word. In sulke gevalle is verbindingspunte aan die staalbewapening van dié pylplengtes wat by die ingang en uitgang van die gedeelte geleë is, aangebring en deur middel van 'n geïsoleerde kabel verbind. 'n Laespanningsweerlig-aflaier is in serie met die kabel geplaas om elektrolitiese korrosie van die bewapeningstaal in die pype te voorkom. Ingeval oormatige weerligstrome in die pypwand vloei, sal die potensiaal wat oor die oorbrugte pylplengtes ontwikkel gou die deurslagspanning van die weerligafleier oorskry, en sodoende 'n bykomende lae-impedansiebaan inskakel. Ongeveer vier myl van die pyp is reeds 'n paar maande lank in gebruik en gedurende hierdie tydperk het minstens een weerligontleding digby die pyp plaasgevind sonder dat skade veroorsaak is.

Daar word beoog om met behulp van toerusting van die Suid-Afrikaanse Buro vir Standaarde die stroompulsvormoë van die pyp te bepaal. Verder sal ook waarnemings van weerligstrome wat in die pyp en die beskermingstelsel vloei, gemaak word.

## 2. Aardingsprobleme

Die grondresistiwiteit wat in sommige gebiede van Suid-Afrika voorkom is waarskynlik van die hoogstes in enige industriële gebied van die wêreld. Redes hiervoor is onder andere die algemene voorkoms van granitiese grond en sandveld, asook die droë winterklimaat en die betreklik langdurige droogtes wat van tyd tot tyd oor groot gedeeltes van die land ondervind word. Dié toestande verskil heeltemaal van dié wat in Europa heers waar reën meer egalig oor die jaar versprei is.

Vir doeltreffende werking van weerligbeskermingsmiddels, soos bogronde aarddrade, is 'n lae aardingsweerstand noodsaaklik. Die eerste donderstorms vroeg in die seisoen wanneer die grond op sy droogste is en die aardingsweerstande

dan hul hoogste waarde het skep dus buitengewone probleme. Daar is ook aanduidings dat 'n groter persentasie wolk-tot-grond-weerligontladings vroeg in die seisoen voorkom.

'n Ander probleem wat in verband met elektrisiteitsverspreiding voorkom is waar 'n kragdraad breek en op die grond val en waar weens die hoë grondresistiwiteit, onvoldoende stroom vloei om die aardfoutbeskermingsisteme in werking te bring. In hierdie geval bly die lyn onder spanning en is 'n bron van gevaar. Elektrisiteitsvoorsieningsondernemings het natuurlik reeds geleer om met hierdie probleem saam te leef en hulle sake dienoreenkomstig te reël. As gevolg van talryke versoeke het die Wetenskaplike en Nywerheidsnavorsingsraad 'n projek onderneem om hierdie moeilike maar belangrike probleem te ondersoek.

Dit skyn byvoorbeeld wenslik te wees om die grondresistiwiteitswaardes van minstens die ontwikkelende gebiede van Suid-Afrika te karteer, met inagneming van die invloed van vog op die verskillende grondtipes. (7, 8) Dit is naamlik noodsaaklik in die beplanning van kraglynroetes dat die slegste aardings toestande wat as gevolg van seisoensvariasies kan optree, inagneneem word.

As eerste stap in hierdie rigting word 'n eksperimentele oorsig onderneem van bestaande instrumentasie en metodes om grondresistiwiteit en voginhoud te bepaal. Wanneer metings in grond met hoë resistiwiteit gedoen word, dit dit van besondere belang dat die keuse van meetinstrumente sorgvuldig oorweeg word, aangesien resultate ernstig beïnvloed kan word. Daar is byvoorbeeld gevind dat met die gebruik van 'n welbekende maak van instrument, waardes verkry is wat minstens 50 persent te hoog was omdat die instrument gebruik is onder toestande wat klaarblyklik nie gedurende die ontwerp voorsien was nie.

Wanneer 'n opname langs 'n roete gemaak word, kan groot skommelings in resistiwiteitswaardes verwag word, nie alleen as gevolg van variasies van die voginhoud nie, maar ook as gevolg van die baie verskillende grondtipes. Die verhouding tussen resistiwiteit en voginhoud van die grond vir metings elke 1,000 vt. oor 'n roete van 28 myl word in Fig. 6 getoon. Metings van die voginhoud is op 'n diepte van 3 voet gedoen en die resistiwiteitsmetings met 'n elektrodespasiering van 10 vt. Die ontleding het getoon dat, soos verwag, daar wel 'n korrelasie tussen voginhoud en resistiwiteit bestaan. Verder is egter gevind dat vir 'n gegewe voginhoud die resistiwiteitswaardes met soveel as 1000 : 1 kan varieer. Hierdie groot bereik van waardes is duidelik nie van direkte praktiese nut nie, maar daar word verwag dat met grondtipe-klassifikasie hierdie variësie baie kleiner gemaak kan word. Hierdie verwagting word versterk deur resultate wat oor 'n korter roete van 6 myl in 'n ander omgewing verkry is. (sien Fig. 6). Daarby word verwag dat die korrelasie verder sal verhoog as die gemiddelde voginhoud van dieselfde volume grond bepaal word as wat deur die meting van die resistiwiteit gedek is. Hierdie was nie die geval met die metings wat in Fig. 6 aangegee word nie.

Met verwysing na die voorgaande is dit duidelik dat die meting van die voginhoud ter plaatse van groot belang is en verskeie meetmetodes word tans ondersoek, veral met die oog

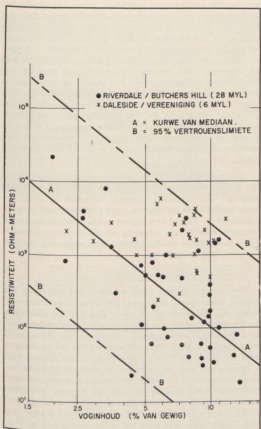


Fig. 6. Verband tussen resistiwiteit (10 vt. diepte) en voggehalte (3 vt. diepte) van grond.

op beter toepasbaarheid in die praktyk. Tot op datum is veral twee metodes wat van kommersieel beskikbare toerusting gebruik maak, getoets. Vir die eerste metode word 'n klein grondmonster vanaf die verlangde diepte verkry deur 'n pyp in die grond te slaan. 'n Bepaalde gewig van die monster word dan met kalsiumkarbid in 'n drukhouer wat met 'n drukmeter toegerus is, gemeng. Die gasdruk wat opgebou word as gevolg van die chemiese reaksie tussen die kalsiumkarbid en die vrye water is direk eweredig aan die persentasie vog van die grondmonster. Die metode bepaal die voginhoud as 'n persentasie op 'n gewigsbasis en het 'n noukeurigheid van beter as 10%. Hierdie metode het die besliste voordeel dat dit eenvoudig en vinnig is om te gebruik, maar die nadeel dat dit onprakties word as monsters vanaf 'n diepte van meer as 3 voet verkry moet word, tensy 'n geskikte boor ontwerp kan word om die grondmonsters te verkry.

Tiptiese voorbeelde van variasies van voginhoud op verskillende dieptes, soos deur hierdie metode bepaal, word in Fig. 7 getoon. Hierdie waarnemings toon duidelik dat die voginhoud aansienlik verander gedurende die verloop van 'n jaar, en dat dit in hierdie besondere geval konsekwent hoër op groter dieptes was. Hierdie is een van die vernaamste faktore wat metings van resistiwiteit met behulp van stroom- en potensiaalelektrodes beïnvloed, en beklemtoon weerrens dat vir akkurate resistiwiteitsmetings dit noodsaaklik is om die grond nie as 'n homogene medium te beskou nie, maar as bestaande uit lae van verskillende resistiwiteite. (9)

'n Ander metode wat gebruik word om seisoensveranderings van voginhoud te bepaal, maak gebruik van vogabsorberende gipsblokkies waarin elektrodes geplaas is. (10) Die weerstand tussen die elektrodes varieer met die voginhoud van die blokkie, wat weer 'n maat is van die voginhoud van die grond waarin die blokkies begrawe is. In praktyk is gevind dat die oorgang van hoër na lae weerstand, as gevolg van 'n toename in die voginhoud, oor 'n baie klein bereik van vogverandering plaasvind. Dit maak die metode onprakties tensy dit alleenlik gebruik word om aan te dui of die voginhoud

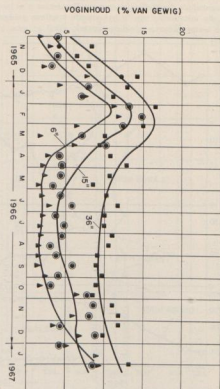


Fig. 7. Verandering van voggehalte van grond op drie dieptes oor 'n periode van 14 maande (Toetsstasie No. 1).



groter of kleiner as 'n kritiese waarde is. Verder kan verwag word dat die kritiese oorgangswaarde sal afhang van die tipe grond waarin die blokkie gebruik word. Dit is egter 'n baie bruikbare metode om die aanwesigheid of afwesigheid van vogtigheid in betreklik ontoganklike plekke, soos byvoorbeeld onder huise of geboue, vas te stel.

'n Verdere eksperiment van belang mag wees, staan in verband met 'n aardingsstelsel wat uit koperdrade met 'n deursnit van 0.025 vk. duim bestaan, on der die fondamēt van 'n woonhuis te Pretoria ingebou is. Die geleier is onder die fondamēt van die buitemure en oor die breedte van die huis begrawe, en het 'n totale lengte van 233 voet. 'n Gipsblokkie is in 'n sentrale posisie onder die gebou geplaas, en 'n tweede blokkie weg van die huis maar op dieselfde diepte, ten einde verglykende metings van die vog onder en weg van die huis te maak. Metings van die weerstand van die aardingsstelsel, die voginhoud en resistiwiteit van die grond is gereeld sedert die aanvang van die bouwerk gedoen, en die resultate tot op datum word in Fig. 8 getoon. Die invloed van die begin van die reënseisoen kan duidelik gesien word.

Die oogmerk van hierdie studie is om te bepaal of hierdie aardingsmetode doeltreffender en meer ekonomies is as byvoorbeeld die installering van 'n bykomende kontinue aardeleier in die laespanningsverspreidingsnetwerk, veral as geen ander

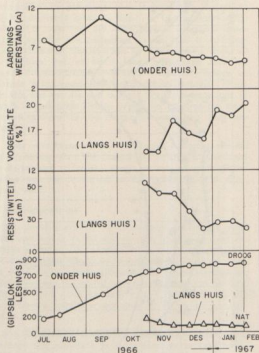


Fig. 8. Veranderinge van aardingsweerstand, voginhoud en resistiwiteit van grond en gipsblokkiesings by 'n woonhuis.

bevreidende aardingsstelsel beskikbaar is nie. In hierdie besondere geval is 'n bogronde staal aardkabel geïnstalleer, en daarby is hierdie aardingsstelsel ook aan die waterleidingstelsel, wat uit staalpipe bestaan, verbind. Die weerstand van hierdie aardingsstelsel was ongeveer 3 tot 4ohm. Alhoewel die fundamentaardingsstelsel 'n hoër aardingsweerstand het, ongeveer 7 ohm, bestaan die moontlikheid egter dat die weerstand vir 'n langer tyd 'n lae waarde sal behou na 'n reënseisoen weens die feit dat die vogtigheid onder die huis langer sal voortduur as in die grond weg van die gebou. Toetse wat vroeër deur die Nasionale Bounavorsingsinstituut van die Wetenskaplike en Nywerheidsnavorsingsraad uitgevoer is, toon byvoorbeeld dat water van onder 'n beskermende oppervlakte uit, baie langamer beweeg as in die teenoorgestelde rigting. (11)

Ander aardingsprobleme wat nog ondersoek moet word, sluit die relatiewe doeltreffendheid van verskillende aardings-elektrodes soos aardmatte, roosters, aardpene en ander bekende konfigurasies in, veral waar die grondweerstand hoog of veranderlik is. Die uitwerking van hoër aardfoutstrome op die aardingsweerstand, veral as gevolg van die maontlike verandering van voginhoud in die onmiddellike omgewing, behoort ook ondersoek te word.

### 3. Termiese Geleiding van Grond

Om kragkabels wat direk in die grond gelê word ten volle te benut is dit nodig om die termiese geleidingsenskappe van die grond self te weet. Die termiese eienskappe van die grond is weer nou verbonde aan die grondpore, graad van kompaktheid en voginhoud. Daar moet ook onthou word dat toestande in Suid-Afrika grotendeels van dié in, byvoorbeeld die Verenigde Koninkryk verskil, en dus bestaan daar 'n behoefte om meer gegewens oor die werklike plaaslike toestande te bekom, of alternatief eenvoudige en goedkoop meetinstrumente beskikbaar te hê. As die termiese geleidingsvermoë onbekend is, bestaan daar die gevaar dat die kabelgrootte wat vir 'n besondere doel spesifiseer word te klein mag wees. Andersins weer word die veilige weg gevolg en word kabels wat groter as nodig is, gebruik wat weer 'n aansienlik groter kapitaalkoste beteken.

'n Verbeterde model van die welbekende sonde (12) wat vir die meting van termiese geleidingsvermoë gebruik word, is plaaslik ontwikkel. Die nuwe sonde bestaan uit 'n pyp met 'n deursnit van 6 mm en 'n lengte van 90 cm met verhittelemente en halfgeleier-diodes vir die temperatuurmeting oor 'n afstand van 38 cm. Die sonde kry 'n konstante kraginset, en die temperatuurverhoging word as 'n funksie van die tyd gemeet.

Aanvanklik is die temperatuurstyging betreklik vinnig weens die plaaslike invloed van die metaal waaruit die sonde bestaan, maar daarna word die styging 'n logaritmiese funksie van tyd soos weergee in die volgende vergelyking:

$$T_2 - T_1 = g \frac{P}{4\pi} \ln \frac{t_2}{t_1}$$

waar  $T_1$  en  $T_2$  die temperatuur van die sonde in °C na verloop van  $t_1$  en  $t_2$  sekondes onderskeidelik is;  $P$  is die kragin-

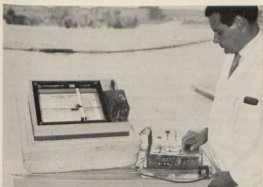


Fig. 9. Foto van apparaat vir die meet van termiese resistiwiteit.

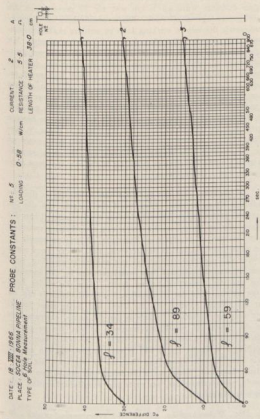


Fig. 10. Tipiese opnames van termiese resistiwiteit.

set in watt per cm lengte van die sonde;  $g$  is die termiese resistiwiteit in  $^{\circ}\text{C}$  per watt;

Hieruit volg dat 'n kromme van temperatuurverhoging ( $T_s - T_1$ ) vs. tyd op 'n logaritmiëse skaal 'n reguit lyn gee waarvan die helling by vaste kraginset eweredig aan die termiese resistiwiteit is.

'n Standaard T-Y-registreeerder is gewysig om 'n logaritmiëse tydbasis te verskaf vir die registrering van die temperatuurstyging van die sonde. Die helling van die finale gedeelte van die grafiek kan maklik bepaal word en verskaf direk 'n waarde van die termiese resistiwiteit. Die apparaat word in Fig. 9 getoon, en 'n tipiese opname in Fig. 10.

Omdat die termiese resistiwiteit van die grond met 'n toename in beide die voginhoud, asook die digtheid afneem, is 'n studie van hierdie parameters nodig ten einde die seisoensvariasie in ag te neem. Hierdie studie word uitgevoer deur weekliks waarnemings by agt toetsplekke in verskillende grondtipes te maak.

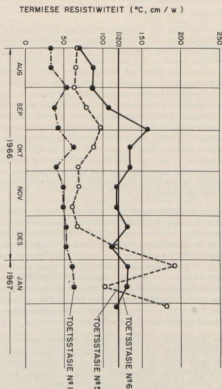


Fig. 11. Verandering van die termiese resistiwiteit van grond by drie toetsstasies oor 'n periode van ses maande, vergelyk met die ontwerpwaarde normaalweg in gebruik.

Termiese resistiwiteit soos op drie verskillende plekke oor 'n periode van 6 maande waargeneem, word in Fig. 11 getoon. Die waarnemings verteenwoordig toestande vanaf droog tot nat. Die waarde van  $g = 120^{\circ}\text{C}$  cm per watt wat algemeen gebruik word wanneer spesifieke gegewens ontbreek, is ingeteken ten einde die groot afwykings vanaf hierdie waarde te illustreer. Teen verwagting in toon hierdie krommes, asook dié wat vir ander toetsplekke verkry is, 'n toename in die termiese resistiwiteit nadat die somerreeën begin het, en dié oënskynlike anomalie moet nog ondersoek word.

In 'n latere referaat sal 'n meer volledige ontleding van die gegewens wat tot op datum versamel is, bespreek word; op hierdie stadium is dit voldoende om te noem dat geskikte instrumentasie, vir vinnige en gerieflike meting van termiese eienskappe van grond onder lokale toestande, binnekort beskikbaar sal wees. Na verwagting sal na afloop van die projek ook voldoende gegewens beskikbaar wees om korreksies vir seisoensveranderings van die voginhoud vir verskeie grondtipes te kan maak.

#### 4. Hoogspanningsnavorsing

##### (a) Hoogspanningsfasiliteite

In vergelyking met die meer gevestigde lande was en bly die groeitempo van die elektrisiteitsvoorsieningsnywerheid in Suid-Afrika nog steeds fenomenaal. Die ingebruikneming van 400 kV-transmissielyste op groot skaal oor die volgende tien jaar is 'n duidelike teken van die vordering en hoë standaard wat reeds bereik is. Andersyds vind 'n groot gedeelte van hierdie ontwikkeling plaas onder omstandighede wat nérens anders sy gelyke het nie; daar is byvoorbeeld min ander intensiewe nywerheidskomplekse vergelykbaar in grootte met dié in die Transvaal wat in 'n gebied lê waar hoë weerligintensiteit, hoë hoogte bo seevlak en betreklike swak grondtoestande gesamentlik voorkom. Nog 'n voorbeeld van die buitengewone omstandighede is die baie groot afstande in die Republiek tussen vragentra, gepaardgaande met die probleem van kragverspreiding in betreklik uitgestrekte en dunbevolkte platte-landse gebiede tussenin.

Navorsingsfasiliteite behoort dus voorsien te word wat met die uitbreiding van elektrisiteitsvoorsiening tred kan hou sodat so veel inligting as moontlik met betrekking tot plaaslike bedryfsomstandighede versamel kan word waarop toekomstige beplanning en ontwerp kan steun. Dit beteken onder andere dat 'n hoogspanningslaboratorium daargestel moet word wat ondersoek in verband met probleme by spannings, selfs hoër as die wat vir die Republiek binne die volgende dekade oorweeg word, moontlik sal maak. Die nodige navorsingspersoneel, wat 'n spesiale opleiding in hoogspanningsmeet-egniek ondergaan het, sal ook verkry moet word.

Die eerste stap in hierdie rigting is reeds geneem deur die totstandbrenging van 'n hoogspannings-koördineringskomitee, wat op 'n vrywillige basis optree en uit verteenwoordigers van belanghebbende organisasies bestaan. Hierdie komitee het die spesifieke taak om 'n oorsig van bestaande fasiliteite en navorsingsprojekte te verkry en gedurende die loop van hierdie jaar aanbevelings te maak in verband met toekomstige beplanning.

Daar word verwag dat op hierdie wyse ten volle gebruik gemaak kan word van die navorsingskragte en -fasiliteite wat reeds in die Republiek aan universiteite en ander inrigtings beskikbaar is, voordat 'n nuwe laboratorium met die gepaardgaande groot uitgawes, opgerig word.

##### (b) Stuspanning op Kraglyne

In 'n projek wat nog in 'n vroeë stadium van ontwikkeling is, word aandag geskenk aan weerlig- en skakelstuspannings op tipiese transmissie- en distribusiestelsels. Die standaardstuspanningswaardes wat gewoonlik by die beplanning van transmissielyste en substasietoerusting gebruik word, is veronderstel om, met inagneming van die beskerming wat van moderne weerligafleiers verkry word, realisties ten opsigte van die werklike werksomstandighede te wees.

Werkomstandighede wissel egter grootliks omdat dit van baie faktore soos byvoorbeeld verwagte aantal weerligontladings, tipe en lengte van kraglyn, aarding, tipe van stroombrekers, ens. afhang. In 'n gebied met 'n bepaalde weerligintensiteit kan 'n ondergeïsoleerde distribusielyn argumentshalwe definieer word as 'n lyn wat vir 50 persent van die weerligspannings sal oorvoek. Die stroombrekers sal dienoreenkomstig dikwels in werking kom en verdere skakelstuspannings veroorsaak. Omgekeerd kan 'n oor-geïsoleerde lyn definieer word as een wat by slegs 5% van die weerligstuspannings sal oorvoek. As die aantal stuspannings wat die gegewe standaardstuspanning oorskry, bepaal kan word tesame met die aantal weerligontladings, sou dit ten minste teoreties moontlik wees om gedurende die ontwerp van sulke distribusielyste 'n isolasiepeil te kies wat die meeste beskerming vir die besondere bedryfsomstandighede sou wees. In hierdie verband is dit vanselfsprekend dat vir kontinue diens, 'n distribusielyn in 'n weerliggebied beter geïsoleer moet word as een wat minder aan weerlig blootgestel is. Die presiese omvang van sulke bykomstige isolering is tot nog toe deur probeer en tref metodes bepaal.

In die geval van die isolering van substasies is die benadering ietwat anders. Hier word die grootte van die inkomende stuspannings grotendeels deur die isolasiepeil van die inkomende lyn bepaal, en die uitwerking op substasietoerusting hang daarvan af of dit 'n endsubstasie of tussensubstasie is, die aantal vertakings in die netwerk, ens. Daar word soms beweer dat die beskermingspeil van substasietoerusting, soos transformators, heeltemal deur weerligafleiers by die aansluitings van die toerusting beheer word. Aan die ander kant moet onthou word dat weerligafleiers nie onfeilbaar is nie, en dat hul leeftyd afhang van die diens wat hulle moet lewer, wat weer grotendeels 'n funksie is van die aantal stuspannings (of dit skakel- of weerligstuspannings is) wat die swigtingswaarde van die weerligafleiers oorskry. Die faling van weerligafleiers, besonder by 11 kV, is niks ongewoons nie en het baie keer 'n reeks sporadiese foute as gevolg voor die finale faling plaasvind. Insgelyks is die faling van transformators as gevolg van stuspannings, ten spyte van weerligbeskerming nog nie uitgeskakel nie.

Die Wetenskaplike Nywerheidsnavorsingraad-projek in verband met hierdie onderwerp het as doel die insameling van

gegewens rakende die aantal en grootte van stuspannings op transmissie- en distribusiestelsels, en die bedoeling is om 'n woonwa vir hierdie doel toe te rus. Basies is die benadering dat soveel gegewens as moontlik op so 'n manier opgeteken word dat 'n statistiese analise maklik en eenvoudig uitvoerbaar sal wees. Inligting sal eers ingesamel word om vas te stel met watter frekwensie die verskillende golfvorms wat optree, teëgekem word, sodat in breë trekke bepaal kan word watter tipes stuspannings oorheers. Die gegewens sal ook die ontwerp van 'n tellerstelsel vergemaklik om rekords van die aantal stuspannings van 'n sekere golfvorm wat 'n voorafbepaald grootte oorskry, te verkry. Die projek moet steun op die medewerking van elektrisiteitsondernemings wat gewillig sal wees om die opname-eenheid toegang te verleen tot die verskillende tipes transmissie- en distribusielyste wat van belang is.

#### (c) Kragonderbreking

In aansluiting by die voorgaande sal dit ongetwyfeld van waarde wees as gegewens wat reeds oor tydperke van jare ingesamel is in verband met die vergelykende prestasie van bestaande transmissie- en distribusiestelsels verkry kan word vir ontledings.

Sover die outeurs weet, word noukeurige aantekeninge van lyn-en substasiefoute en van beskadigde toerusting deur die meeste elektrisiteitsondernemings gemaak, en baie ondernemings ontleed hierdie gegewens ten opsigte van faktore soos roetelengtes, aantal substasies, toerusting wat gebruik word, ens. Sulke rekords is van die grootste waarde vir die ondernemings self om die vergelykende prestasie van verskillende tipes stelsels of van verskillende fabrikate van toerusting, soos byvoorbeeld weerligafleiers te bepaal. Die nuttigheid van sulke gegewens kan aansienlik vermeerder word as dit gebruik word om 'n vergelyking te tref tussen die prestasies van die netwerke van 'n aantal elektrisiteitsondernemings van verskillende tipes. 'n Standaardmetode sal ontwerp moet word ten einde die opneem van gegewens en die latere verwerking doeltreffend en die resultate vergelykbaar te maak. Sodanige gegewens sou ook van belang wees wanneer bepaal moet word of 'n besondere stuk navorsingswerk noodsaaklik is.

#### 5. Verdere Kragingenieurswese-probleme

Ofskoon baie van die probleme in verband met elektrisiteitsvoorsiening na jarelange ervaring reeds opgelos is, bestaan daar geen twyfel dat ander probleme as gevolg van vinnige uitbreiding sal opduik nie, veral omdat dit steeds belangriker word om kostes binne redelike grense te hou. Trouens, terwyl daar nog sekere basiese en fundamentele probleme onopgelos is, blyk dit dat die klem by navorsing al meer en meer op 'n ondersoek van die ekonomiese, in plaas van die suiwer fundamentele aspekte van sulke stelsels gelê word. Natuurlik word die omvang van die navorsingswerk wat onderneem kan word deur die beskikbaarheid van navorsingsingenieurs en die navorsingsfasiliteite beperk.

'n Paar bykomende probleme wat in die Afdeling Elektriese Kragingenieurswese aandag geniet, is n.l. die ontwikkeling van metodes om die breek van 'n geleier outomaties vas te stel; metodes vir die vinnige meting van die dikte van bo-

grondse kontakdrade in elektriese traksie; kragomsetting van wisselstroom na gelykstrom en omgekeerd; toepassings van silikon-beheerde gelykstrigters.

Verdere probleme wat reeds identifiseer is en moontlik in die toekoms as navorsingsprojekte onderneem sal word, is elektriese voertuie met batteryaandrywing; metodes van lasvoorspelling; die intrinsieke gedrag van isolasie onder die invloed van hoë spanning; die elektriese eienskappe van houtsoorte wat in Suid-Afrika gekweek is; en die aanwending van elektrisiteit by landbou en tuinbou.

### NAVORSING VAN DIREKTE BELANG VIR ELEKTRIESE KRAGINGENIERSWESSE

#### 1. Outomatisasie

Op die gebied van outomatisasie word navorsingswerk in die Afdeling Outomatisasie van die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe tans veral toegespits op die ontwikkeling en toepassing van syfer tegnieke in datahantering en beheer. Verskeie toepassings om wetenskaplike eksperimente te beheer en die waarneming in syfer vorm op te berg op 'n geskikte medium vir direkte invoer in 'n syferrekenaar vir verdere ontleding, is reeds deurgevoer, soos byvoorbeeld 'n outomatiese weerstasie, 'n beheer vir 'n X-straaldiffraktometer, ens. Hierdie werk word nou uitgebrei na 'n studie van die gebruik van syferrekenaars in prosessebeheer.

Daar is tans reeds meer as 1,000 syferrekenaars in prosessebeheer insalleer, waarvan ongeveer 25% in die kragopwekingsnywerheid is. Navorsing op hierdie gebied is van direkte belang vir die kragingenieur in soverre dit deesdae algemeen aanvaar word dat wanneer 'n opwekkingseenheid 200 na 250 megawatt kapasiteit het, 'n syferrekenaar in beheer selfs bloot as 'n waghoud geresigdig kan word. Die 2% tot 24% hoër doeltreffendheid wat deur so 'n beheer verkry word, word bloot as 'n bonus beskou. (12, 13)

Gebrek aan geskoolde arbeid, veral van toesighoudende personeel in kragstasies in die Republiek, kan die toepassing van hierdie tipe van beheer ook in kleiner stasies in die toekoms noodsaaklik maak. Die betroubaarheid van hierdie tipe beheerstelsel is deesdae sulks dat die gevaar waarna gewoonlik spottenderwys verwys word, n.l. van een toesighouer wat verplaas word deur twee onderhoudspersoneel, nie langer van toepassing is nie.

#### 2. Halfgeleierelemente

Werk op die gebied van die toepassing van halfgeleiers wat in die Afdeling Elektronika van die Vaste Toestand van die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe gedoen word, is ook van direkte belang vir die kragingenieur. Halfgeleierelemente vind al meer en meer toepassing in die kragnywerheid en probleme wat met gebruik onder plaaslike toestande ontstaan, kan direk steun op kennis wat in die navorsingslaboratorium opgedoen word. Die kragingenieur betree hier 'n vir hom onbekende wêreld waar oorgangsverskynsels wat in nanosekondes gemeet word die vernietiging van halfgeleierelemente in verkeerdik ontwerpde stroombane kan beteken. Nogtans, indien die nodige voorsorg getref word, kan hierdie elemente heeltemal nuwe toepassingsmoont-

likhede vir die kragingenieur skep. Die baie hoë betroubaarheid wat reeds met halfgeleierelemente verkry is, sal na verwagting nog verder verhoog met die gebruik van mikrostrombane. (15)

Werk op die gebied van onkonvensionele energiebronne word in die Afdeling Toegespede Elektronika van die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe gedoen waar die omsetting van sonenergie of termiese energie, direk na elektriese krag, gedoen word. Met die beskikbaarheid van moderne halfgeleier-termo-elektriese eenhede en sonselle, word hierdie elemente van belang ook vir die kragingenieur vir toepassings in afgeleë plekke waar dit soms nuttig gebruik kan word vir aandrywing van instrumente of kommunikasietoerusting.

### 3. Telekommunikasie

Telekommunikasie is 'n onontbeerlike hulpmiddel vir die kragingenieur. Navorsingswerk op telekommunikasie in die Nasionale Instituut vir Telekommunikasie navorsing is in twee breë rigtings verdeel, nl. die studie van radiokommunikasie as sulks asook die toepassing van radiogolwe om ander probleme op te los.

Onder die direkte studie van radiokommunikasie ressorteer studies van die invloed van die atmosfeer op die voortplanting van radiogolwe asook 'n studie van die ionosfeer en die invloed op kortgolfvoortplanting. Toepassing van radiogolwe op ander terreine is byvoorbeeld die gebruik van radar om reëval te meet en die gebruik van elektromagnetiese golwe vir afstandsmeting. Hieronder val die welbekende sisteme soos die Tellurometer en Terrafix.

### 4. Elektriese Standaarde

Die noodsaaklikheid van gereelde yking van meetinstrumente is aan elke ingenieur bekend. Enige substandaard wat in die yking van gewone meters gebruik word, moet op sigself weer met meer noukeurige standaarde vergelyk word, wat op hulle beurt weer vergelykbaar met internasionale standaarde moet wees. Die instandhouding van die fundamentele standaarde vir elektrisiteit in die Republiek word, soos reeds gesê, deur die Nasionale Fisiese Navorsingslaboratorium onderneem.

'n Navorsingsprogram vir die konstruksie van 'n absolute kapasitor, waarvan die waarde in terme van lengtemetings bereken kan word, is tans aan die gang. Hiervan kan 'n absolute standaard van weerstand en uiteindelik van spanning afgelei word.

Tot tyd en wyl hierdie projek voltooi is, word die fundamentele standaarde gehou in die vorm van standaardsele, standaardweerstande en standaardkapasitors wat kopieë is van soortgelyke items wat in buitelandse laboratoria gehou word. Die noukeurigheid van hierdie standaarde kan terugverwys word tot die standaarde wat in die Internasionale Buro vir Mate en Gewigte in Parys, Frankryk, gehou word.

### 5. Verligting

Die Nasionale Bounavorsingsinstituut doen heelwat navorsing op die gebied van verligting en hoewel dagligverlig-

ting as gevolg van gunstige plaaslike toestande voorrang geniet, word kunsmatige verligting nie verwaarloos nie. So byvoorbeeld is aandag reeds gegee aan aspekte soos sekuriteitsverligting van geboue, strukture en terreine in die algemeen en die kunsmatige verligting van klaskamers, tekenkantore, kunsmuseums, fabriek, hospitale en tennisbane. (16, 17)

Hierbenevens dien personele van die Instituut ook op verskillende Komitees van die Suid-Afrikaanse Buro vir Standaarde wat verligting en verwante aspekte hanteer. So ook is die sekretariaat van die Suid-Afrikaanse Nasionale Komitee vir Verligting in die Instituut gesetel. Uitstekende samewerking is reeds bewerkstellig met die Internasionale Kommissie vir Verligting en die hoofdoel van die Komitee is, net soos die geval met die navorsing is, om verligtingsontwerp hier te lande op 'n wetenskaplike grondslag te plaas.

### 6. Kragvoorsiening vir Huise

Om kosteredes is daar tans baie bantoe woonbuurtes waar elektrisiteit nie voorsien word nie, maar die stygende lewensstandaard van die Bantoe en die daarmee gepaarde vermoë om dit te kan bekostig, beteken dat die voorsiening van elektrisiteit in sulke woonbuurtes in die nabye toekoms algemeen sal word. 'n Opname wat tans deur die Nasionale Bounavorsingsinstituut deurgevoer word, behoort aanduidings te gee van die omvang en geardeid van sulke dienste.

### 7. Wiskundige Statistiek

Die toepassing van wiskundige statistiek in die beplanning van eksperimente en in die ontleding van die resultate het 'n uiters belangrike aspek van navorsing geword en word aktief in die Afdeling Statistiek van die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe beoefen. Toepassings is nie net in navorsing van belang nie, maar ook op die gebied van beplanning en ander praktiese probleme wat die ingenieur mag teëkom.

'n Voorbeeld van hoe wiskundige statistiek gebruik kan word om die elektriese ingenieur met beplanning te help, is 'n studie van die lewensduur van sekere elektriese of elektroniese komponente. (18) Die lewensverdeling van sulke komponente (byvoorbeeld straatlampe) en sekere wiskundige parameters van hierdie lewensverdelings (verwagte lewensduur, swigtempo ens.) is van belang by die bepaling van, byvoorbeeld, 'n optimale onderhoude- of vervangingsbeleid. 'n Gebruiklike vervangingsbeleid, wat bekend staan as ouderdomsvervangings, is dat elke individuele eenheid 'n vasgestelde aantal ure na sy inwerkingstelling vervang word, behalwe as dit vroër as gevolg van faling moet geskied. 'n Alternatiewe vervangingsbeleid staan bekend as blok-vervangings — 'n hele blok van eenhede word vervang na gereelde tydsintervalle, ongeag die falingsgeskiedenis van die sisteem. Deur die toepassing van statistiese metodes kan 'n vergelyking tussen verskillende vervangingsbeleide getref, en die beleid aanbeveel word, wat maksimum-doeltreffendheid lever teen minimum-koste. Die wiskundige modelle wat ter sake is, is gewoonlik nie eenvoudig nie, veral wanneer ingewikkelde sisteme betrokke is. Die gespesialiseerde kennis van die statistikus en die elektriese ingenieur gesamentlik is hier noodsaaklik.

## 8. Numeriese Analise

Die gebruik van numeriese tegnieke vir die oplossing van probleme het die afgelope twee dekades 'n metamorfose ondergaan as gevolg van die fenomenale ontwikkeling op die gebied van systerrekenaars. Die Wetenskaplike en Nywerheidsnavorsingsraad het tans 'n goed-toegeruste IBM 360 model 40 wat onlangs sy IBM 704 vervang het. Hierdie rekenaar word hoofsaaklik vir ondersoekte in die Wetenskaplike en Nywerheidsnavorsingsraad gebruik, maar is ook beskikbaar vir buite-standers vir die oplos van wetenskaplike en tegnologiese probleme.

Voorbeelde van probleme wat reeds deur die Afdeling Numeriese Analise van die Nasionale Navorsingsinstituut vir Wiskundige Wetenskappe met behulp van die rekenaar opgelos is, is 'n verkeersontleding en roete-beplanning vir binne-stedelike verkeer, uitgevoer deur die Pretoria se Munisipaliteit; 'n ontleding van grootskaalse opnames van tussen-stedelike verkeer by opepad-beplanning; dergelike ontledings van grootskaalse opnames van gegewens oor verkeersongelukke, en 'n groot verskeidenheid van ander statistiese ontledings.

'n Studie wat veral vir elektriese ingenieurs van belang is, is die outomatisering van alle landmeetkundige berekeninge vanaf die veldboek tot die finale kartografiese data met voorsiening vir 'n willekeurige volgorde van waarnemings en vir ingryping van die landmeter in die verloop van die berekening. (19) 'n Prosedure is verder ontwikkel vir ekonomiese plasing van transmissietorings langs 'n roete beginnende met die veldboekdata van die roete-opname. (20) Die kriterium vir die plasing van die torings is die handhawing van 'n voorskryfde veilige afstand van die geleier na die naaste grondoppervlak.

Die gebruik van die rekenaar in studies van vragvoorspeling is natuurlik ook 'n voor-die-hand-iggende maatskappij toepassing.

## AANVERWANTE NAVORSING

### 1. Lugbesoedeling

Die Nasionale Fisiese Navorsingslaboratorium van die Wetenskaplike en Nywerheidsnavorsingsraad is vir geruime aantal jare reeds besig om metings te doen op lugbesoedeling veral veroorsaak deur rook, swaeldioksied en stof. Hierin het hulpe onder andere die samewerking van die stadsrade van Johannesburg, Durban, Germiston en Kaapstad gehad. Die geweldig omvang wat die probleem van lugbesoedeling reeds in Suid-Afrika aangeneem het, het daartoe gelei dat die Wet op Voorkoming van Lugbesoedeling in 1965 gepromulgeer is. Hierdie Wet dek 'n baie wye veld en is ook van direkte belang vir die elektriese kragingenieur aangesien dit lugbesoedeling as gevolg van kragopwekking deur verbranding van steenkool raak.

Dié navorsing van die Wetenskaplike en Nywerheidsnavorsingsraad is van belang aangesien dit die moontlikheid daarstel om meer te wete te kom van faktore wat lugbesoedeling beïnvloed. So is daar reeds navorsing gedoen oor die redes vir die stagnante atmosfeer oor Durbanhawe, wat 'n opbouing van besoedeling veroorsaak. Ander projekte was 'n

ondersoek na die termiese doeltreffendheid van 'n vertikale stoomketel, 'n ondersoek na die gebruik van steenkool deur verskillende verbruikers in die nywerheidsgebiede van die Transvaal, ens. (21, 22, 23)

### 2. Stabiliteit van Strukture

Die Afdeling Lugdinamika van die Nasionale Navorsingsinstituut vir Meganiese Ingenieurswese beskik oor 'n opstraal-windtonnel met 'n deursnit van 10 voet waarin windshelde van 40 vt. per sekonde, en 'n toestraalwindtonnel met 'n deursnit van 24 duim en waarin windshelde tot 100 vt. per sekonde, bereik kan word. Met die beskikbare fasiliteite kan die Afdeling 'n groot verskeidenheid lugdinamika-probleme ondersoek, o.a. die uitwerking van windbelasting op geboue en ander strukture soos torings, ens.

### 3. Grondstruktuur

Die bepaling van grondstabiliteit en ander parameters wat belangrik is sower dit die daarstelling van 'n geskikte fondament vir 'n gebou of transmissietoring raak, is natuurlik ook van belang vir die kragingenieur. 'n Aantal projekte in die Wetenskaplike en Nywerheidsnavorsingsraad het gelei tot die ontwikkeling van toerusting wat direk toepaslik is vir hierdie tipe van probleem en word dus interessanthalwe genoem.

#### (a) Kortafstand-Seismiese-eenheid

Die seismiese tegniek om inligting in verband met die aardstruktuur te bekom is natuurlik welbekend aan geleë. Die normale tegniek om van 'n plofstof gebruik te maak om die nodige seismiese energie in die grond op te wek en die meting van skokgolwe met geofone, word toegepas wanneer tot redelik groot dieptes eksploreer word. Meer onlangs is 'n aantal instrumente ontwikkel vir kortafstand-eksploratie wat veral nuttig is vir die bepaling van die grondstruktuur in die boonste lae. (24) Die bron van seismiese energie is 'n 10 lb. hamer waarmee die grond geslaan word en die gewone seismiese optelkoppe word dan gebruik om die voortplanting te meet. Die tydinterval tussen die hammerslag en die aankoms van die skokgolf by the seismometer word outomaties gemeet en op die instrument vertoon. Hierdie metings word dan tesame met die afstand tussen die hamer en die geoffoon grafies opgeteken. Vanaf hierdie grafieke is dit moontlik om die voortplantingspoed van klank in die verskillende lae te bereken: inligting wat direk van nut is om sekere van die eienskappe van die grond in die verskillende lae af te lei.

#### (b) Boorgatkamera

'n Boorgatkamera is ontwikkel om die teenwoordigheid van ondergrondse holtes soos byvoorbeeld sinkgate te bepaal en om die grootte van hierdie holtes benader vas te stel. Die sonde is 1½ dm. in deursnit en 3½ vt. lank en bevat 'n foto-elektriese detektor en 'n kamera. Die detektor word gebruik om die teenwoordigheid van die holte vas te stel, en aan te dui waar die holte begin en ophou. Die eenheid word in die boorgat afgelaat deur middel van 'n aantal stange wat in 'n spesiale driepoot en draaitafel monter is. Sodra die teenwoordigheid van 'n holte waargeneem is, word die kamera gebruik om fotos op verskillende dieptes en in verskillende rigtings te neem. Ongeveer 12 fotos word op 'n bepaalde diepte geneem om die volle omtrek van die holte te dek.

#### 4. Akoestiek van Geboue

In die Akoestiekafdeling van die Nasionale Fisiese Navorsingslaboratorium is 'n uitgebreide navorsingsprogram op die gebied van Argitektoniese Akoestiek reeds 'n geruime tyd aan die gang. Hierdie werk het begin met die opstel van Afrikaanse spraakverstaanbaarheids-woordlyste. Hierna is die integrasie-eienskappe van die menslike gehoorsisteam vasgestel deur middel van 'n reeks subjektiewe toetse op 'n groot aantal proffersone. Hiervolgens was dit moontlik om presies vas te stel watter invloed vertraagde weerkaatsings in 'n saal op die verstaanbaarheid van spraak het. 'n Meetkriterium kan gevolglik daargestel word waarvolgens die verstaanbaarheid van spraak in 'n saal objektief bereken kan word uit 'n ontleding van die weerkaatsingspatroon in die saal. (25) Deur middel van modelstudies is hierdie werk uitgebrei sodat dit nou moontlik is om, met behulp van 'n 1/16-skaal-akoestiese model van 'n nuwe gehoorsaal, te voorspel wat die verstaanbaarheid van spraak in die saal sal wees nog voordat dit gebou word. (26) Deur die vroegtijdige vasstelling van ontwerfoute kan dus groot bedrae geld bespaar word. Hierdie werk word tans voortgesit en daar word gesoek na 'n meetkriterium wat op die gebied van konsertsalaakoestiek toegepas kan word.

#### 5. Metaalkorrosie

Metaalkorrosie kan aan bande gelê word deur die oorsake daarvan wetenskaplik te ondersoek en dan middelle ter voorkoming daarvan aan te wend. (27,28) Die Korrosiegroep van die Wetenskaplike en Nywerheidsnavorsingsraad spits hom daarop toe om korrosieprobleme van Staatsdepartemente, plaaslike owerhede en die nywerheid te ondersoek, en oplossings daarvoor aan die hand te doen. In sommige gevalle kan dadelik raad gegee word, maar dikwels moet eers grondige ondersoek na die probleem ingestel word.

Daar is onder andere op verskeie plekke in die Republiek blootstellingstoetse kragtens kontrak uitgevoer om vas te stel hoe gou sekere metale en metaaldeklare in die atmosfeer korrodeer. Daar gaan ook binnekort op verskeie uitgesoekte plekke begin word met blootstellingstoetse op uitgebreide skaal vir die meeste metaalsoorte in algemene gebruik om 'n korrelasie te soek met gegewens oor lugbesoedling, die soutgehalte van die lug en weertoestande.

#### ERKENNING

Die outeurs wil graag hulle dank uitspreek teenoor direkteure van ander institute in die Wetenskaplike en Nywerheidsnavorsingsraad wat inligting tot hulle beskikking gestel het asook aan die talle ander kollegas wat meegehelp het. Mnr. P. Levesque se toestemming om te mag verwys na werk wat onder kontrak vir sy maatskappy uitgevoer is, word met dank erken.

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#### OPSOMMING

Navorsingswerk wat tans in die Wetenskaplike en Nywerheidsnavorsingsraad aan die gang is op die gebied van elektriese kragingenieurswese word gedek. Daar word verwys na werk op die gebiede van weerligmetings en weerligbeskerming, aardingsprobleme en termiese geleiding van grond. Op die gebied van hoogspanningsnavorsing word die behoefte vir voldoende fasiliteite bespreek en ook melding gemaak van spanninge op kraglyne en kragonderbrekings. Verskeie ander probleme word genoem.

Daarnaas word navorsing wat van direkte belang vir elektriese kragingenieurswese is, soos outomatisasie, halfgeleier-elemente, telekommunikasie, elektriese standaarde, verligting, wiskundige statistiek en numeriese analise kortliks bespreek.

Verder word kortliks na aanverwante navorsing wat vir elektriese kragingenieurs van belang is, soos byvoorbeeld lug-besoedeling, stabiliteit van strukture, akoestiek van geboue en metaalkorrosie verwys.

#### SUMMARY

Research currently taking place at the Council for Scientific and Industrial Research in the field of power electrical engineering is covered. In particular work on lightning measurements and lightning protection, earthing problems and thermal conductivity of soil, is covered. In the field of high voltage research the necessity for adequate facilities is discussed and mention is made of work concerning surges on transmission lines and power interruptions. Several other problems are mentioned.

In addition, research work in fields which are of importance to power electrical engineering, such as automation, semi-conductors, telecommunications, electrical standards, illumination, mathematical statistics and numerical analysis is briefly discussed.

Further, brief reference is made to associated research which is of importance to power electrical engineers such as air pollution, stability of structures, building acoustics and metal corrosion.



**REPORT ON THE  
TRAINING OF ENGINEERS AND TECHNICIANS**

Sub-committee:

G. C. Theron (Convener), R. Leishman, C. Lombard

Arising from a discussion at the Technical Meeting of the A.M.E.U. held at Bloemfontein in May, 1966, a sub-committee was appointed . . . to consider the Straszacker report on the training of engineers and anticipated State Action on the training of apprentices with particular reference to differentiation between artisans and technicians.

A memorandum submitted by Councillor H. G. van Zyl to the Municipal Association of Transvaal was also considered by the Sub-committee as falling within the scope of its terms of reference.

The Executive Council of the A.M.E.U. considered the report of the said subcommittee and at the meeting held in November, 1966 resolved to comment as follows:-

1. The Straszacker Commission took 8 years to prepare the report which is still under consideration by the Government. Until the decisions of the Government in this connection are made known it is possible to deal with the problem on the basis of principles only.
2. The image of the engineer has to be improved in order to draw new recruits into the profession: If the recommendation of the Borkenhagen commission viz that local authorities should be responsible for distribution of electricity only, is literally and completely accepted then municipal electricity undertakings will become resale organisations with a limited appeal to qualified engineers.
3. The Straszacker report, paragraph 669 reads:-  
"Even with extensive use of consultants, public bodies, particularly the larger ones, still require an adequate force of the best available engineers in their employ, because ultimately they have to determine engineering policy. This cannot be done effectively by outside engineers."

And paragraph 671 reads:-

"The remuneration of engineers must be based on their value to the community. Such remuneration is not necessarily related to the salaries applicable to other groups in an organisation."

The competition for experienced and well qualified engineers from employers outside of Municipal organisations is very strong and although the judicious use of engineering assistants can help to cope with the work, a strong core of experienced engineers must be ensured.

The provision of services, motorways and other engineering services are assuming tremendous proportions in the modern community and requires the management and control of engineers of the highest calibre.

4. The seriousness of the present situation is indicated by the almost complete absence of municipal engineers in

**VERSLAG OOR DIE  
OPLEIDING VAN INGENIEURS EN TEGNICI**

Subkomitee:

G. C. Theron (Sameroper), R. Leishman, C. Lombard

Voortvloeiende uit die bespreking op die tegniese vergadering van die V.M.E.O. gehou te Bloemfontein in Mei 1966, is 'n subkomitee benoem om . . . die Straszacker verslag oor die opleiding van ingenieurs en beoogde staatsoprede in verband met die opleiding van vakleerlinge te oorweeg, met spesiale verwysing na die onderskeid tussen tegnisi en ambagsmanne. 'n Memorandum ongestel deur Rds. H. G. van Zyl vir die Munisipale Vereniging van Transvaal het ook binne die opdrag van die subkomitee geval en is ook oorweeg.

Die uitvoerende raad van die V.M.E.O. het op 'n vergadering gehou in November 1966, die verslag van die subkomitee oorweeg en besluit om soos volg kommentaar te lewer:

1. Die Straszacker-kommissie het 8 jaar geneem om die verslag wat nog deur die Regering oorweeg word, voor te berei. Tot tyd en wyl die besluite van die Regering in die verband bekend is, kan die saak net op die grondslag van beginsels bespreek word.
2. Die beeld van die ingenieur moet verbeter word ten einde huwelinge na die professie te trek. Indien die aanbevelings van die Borkenhagen-kommissie nl, dat plaaslike besture net vir die verspreiding van elektrisiteit verantwoordelik moet wees, letterlik en algemeen aanvaar word dan sal munisipale elektrisiteitsondernemings verkoopsgoedertalige organisasies word met 'n beperkte aantreklikheid vir gekwalifiseerde ingenieurs.
3. Die straszacker-verslag, paragraaf 669 lees:-  
"Selfs met die uitgebreide gebruik van konsultante het openbare liggame, vernameamlik die groteres, nog nodig om voldoende goeie ingenieurs in diens te neem want op slot van rekening moet hulle op ingenieursvlak, beleid bepaal. Dit kan nie doeltreffend deur buite ingenieurs gedoen word nie." (vertaling).

En paragraaf 671 lees:-

"Die besoldiging van ingenieurs moet gebaseer word op hulle waarde vir die gemeenskap. Sulke vergoeding hou nie noodwendig verband met die salaris van toepassing op ander groepe in die organisasie nie." (vertaling).

Die aanvraag deur werkgewers buite die munisipale organisasies om goeie opgeleide ingenieurs met ondervinding is baie sterk en alhoewel die oordeelkundige gebruik van ingnieursassistentes kan help om die hoof te bied, moet 'n gesonde kern van ervare ingenieurs verseker word. Die voorsiening van dienste, deurweë en ander tegniese dienste neem geweldige afmetings aan in die moderne gemeenskap en benodig die bestuur en beheer van ingenieurs van die hoogste gehalte.

4. Die erns van die situasie word onderstreep deur die amper volke afwesigheid van munisipale ingenieurs

the 40 - 50 age group. After gaining some experience the young engineer is snatched away by industry, the munitions and aircraft factories etc. from municipal and semi-state organisations with salaries tied to the civil service.

5. By way of summarising we
  - (i) fully endorse the Straszacker report and consider that the extensive researches, suggestions and recommendations are to be commended; and
  - (ii) must draw attention to the repercussions of the Borkenhagen report suggesting an Escom monopoly which threatens to lead Local Authorities into a dearth of Mechanical and Electrical Engineers and to relegate this category more to the status of technicians. This can develop into a very serious situation as pointed out in the Straszacker report. Recent Provincial legislation limiting the salaries of Town Clerks has a similar effect.
6. The A.M.E.U. is in agreement with the general principles as expounded by Cnl. van Zyl but must point out that there are fundamental differences between civil engineers and their work and that of the electrical and mechanical branch of municipal engineering. The memorandum deals essentially with the training of civil engineering assistants and the difficulties which will be experienced in the other branches must therefore be pointed out.
7. Electrical and mechanical work in local authorities cannot be confined to municipalities only and training should be on a broad basis. Specialist training with the purpose of tying the employee to the employer group tends to frighten the better type away. See also Straszacker report R/49:  
"that engineers in the service of the State be free to change their employers without restriction."
8. Development in the field of electrical and mechanical engineering is very fast and appliances using new and refined principles are being brought into use every day. The demand for specialists is becoming more and more evident and there is therefore a need for a special class of artisan and technical assistant which must, however, have a broad basic training with specialist training in a particular undertaking. These people will only be retained by applying special salary grades.
9. Training schemes for Mechanical and Electrical Engineering Assistants along the lines suggested by Cnl. van Zyl are about to be started by Johannesburg City Council according to recent press reports.
10. The training scheme should not draw its recruits from the artisan class only but from all sections with the required qualifications. This will widen the field for recruits.
11. Only Local Authorities with qualified engineers and staff and training facilities should be allowed to under-

in die 40 - 50 ouderdomsgroep. Nadat 'n bietjie onder-vinding opgedoen is, word die jong ingenieur deur die nywerhede, die ammunisie- en vliegtuigfabrieke weggetrek van munisipale en semistaatsorganisasies met salarisse aan dié van die staatsdiens gekoppel.

5. Opsomming:-
  - (i) Die Straszacker-verslag word heelhartig ondersteun en die uitgebreide navorsing, voorstelle en aanbevelings word sterk aangeprys.
  - (ii) Daar moet aandag gevestig word op die nagevolge van die Borkenhagen-verslag wat 'n EVKOM monopolie voorstel en wat 'n skaarste van werktuigkundige en elektrotegniese ingenieurs by plaaslike besture kan veroorsaak en die status van die groep tot die van tegnici kan afbring.
- Soos in die Straszacker-verslag uitgewys kan dit tot 'n ernstige situasie ontwikkel.  
Onlangse provinsiale wetgewing wat die salarisse van stadsklerke pen het 'n soortgelyke uitwerking.
6. Die V.M.E.O. steun die algemene beginsels soos deur Rds. van Zyl uiteengesit maar moet uitwys dat daar fundamentele verskille is tussen siviele ingenieurs en hulle werk en die van die elektriese en meganiese vertakkinge van munisipale ingenieurswese. Die memorandum handel hoofsaaklik met die opleiding van siviele ingenieurs-assistente en die probleme wat in ander afdelings onder-vind sal word moet uitgewys word.
7. Elektriese en meganiese werk in plaaslike besture kan nie tot munisipaliteit beperk word nie en opleiding moet op 'n breë vlak wees. Gespesialiseerde opleiding met die doel om die werknemer tot die spesifieke werkgewers-groep te bind het die neiging om die beter tipe af te skrik. Sien ook Straszacker-verslag R/49:-  
"ingenieurs in diens van die Staat moet vry wees om van gewerger te verander sonder beperking." (vertaling).
8. Ontwikkeling op die gebied van elektriese en meganiese ingenieurswese is baie vinnig en toerusting met nuwe en verfynde beginsels word daaglik in gebruik geneem. Die vraag na spesialiteite word steeds duideliker en daar is derhalwe 'n behoefte aan 'n spesiale klas van ambags-man en tegniese assistent met gespesialiseerde opleiding in 'n besondere onderneming maar met 'n breë basisse opleiding. Hierdie klas van persone sal net behou kan word op spesiale salarisskale.
9. Opleidingskemas vir elektrotegniese en meganiese ingenieurs-assistente soos deur Rds. van Zyl aan die hand gedoen word, volgens onlangse persverslae, binnekort deur die Stadsraad van Johannesburg in werking gestel.
10. Die opleidingskema moet nuwelinge nie net uit die ambags-groep trek nie maar uit alle sektors met die nodige opleiding. Dit sal die veld vir nuwelinge vergroot.
11. Net plaaslike besture met gekwalifiseerde ingenieurs en personeel en die nodige opleidingsfasiliteite moet toege-

take the training of the technical assistants in order to ensure a satisfactory level of trainee.

12. Salaries cannot be uniform as this will be affected by various outside factors, such as housing, cost of living, etc.
13. The technical colleges should also do some ad hoc training to show the pupil what the plant looks like and how it works as at Germiston.
14. In agreeing with the general principles of the memorandum the A.M.E.U. proposed the setting up of a National Committee representative of the A.M.E.U., technical colleges, government departments concerned and other interested parties with power to guide and direct but flexible to approve the service conditions and training according to individual circumstances. The training scheme of various employers will be considered by the steering committee and tried and ultimately a National scheme can be evolved.
15. Special attention should be paid to the teaching personnel both at the colleges and in the field.
16. It is also suggested that there should be closer co-operation with the army training schemes to ensure that during the military training period interested youths are placed in technical units where, in addition to military training they can receive basic technical instruction to prepare them for an engineering career.

G. C. THERON,  
Convener

13th February, 1967

#### ANNUAL REPORT ON THE ACTIVITIES OF THE PHYSICS AND ELECTRICAL ENGINEERING DEPARTMENT OF THE S.A. BUREAU OF STANDARDS

Co-ordinating Representative: G. C. Theron.

##### 1. COMPULSORY SAFETY SPECIFICATIONS

Amendment No. 1 to the compulsory standard specifications for electrical equipment was published in Government Gazette No. 1430 of 22nd April, 1966.

The proposed amendment No. 2 was issued in Government Gazette No. 1628 of 6th January, 1967.

Since July 3, 1965, when the compulsory specifications came into force, to date, the Bureau has found little difficulty with the administration of the compulsory specifications and has found industry and trade to be most helpful and co-operative.

It has been found, however, that certain anomalies arise due to the fact that certain accessories and flexible cords (Schedules 1, 4, 6, 9 and 10) are not confined to the apparatus

laat word om tegniese assistente op te lei ten einde 'n bevredigende endproduk te verseker.

12. Salarisse kan nie eenvormig wees nie aangesien dit beïnvloed word deur buitefaktore soos behuising, lewenskoste, ens.
13. Die tegniese kolleges moet ook 'n sekere mate van ad hoc opleiding doen om die leerlinge te wys hoe die toerusting lyk en hoe dit werk soos die geval is by Germiston.
14. Terwyl daar met die algemene beginsels in die memorandum saamgestem word, wil die V.M.E.O. voorstel dat 'n nasionale komitee bestaande uit verteenwoordigers van die V.M.E.O., die tegniese kolleges, staatsdepartemente daarby betrokke en ander belanghebbendes saamgestel word om leiding en opdragte te gee maar moet die diensvoorwaardes en opleiding aanpas en goedkeur na gelang van die afsonderlike omstandighede. Die opleidingskemas van die verskillende werkgewers kan oorweeg word deur die komitee, uitgetoets word en later kan daaruit 'n nasionale skema ontwikkel.
15. Spesiale aandag moet geskenk word aan die doserende personeel by die kolleges en ook in die praktyk.
16. Daar word ook aan die hand gedoen dat daar nouer samewerking met die weermag se opleidingskemas moet wees. Dit sal verseker dat gedurende die militêre opleidingstydperk, die jeug wat in die rigting belang stel, in tegniese eenhede geplaas sal word waar hulle saam met die militêre opleiding ook basiese onderrig sal ontvang in tegniese vakke in voorbereiding vir 'n loopbaan in ingenieurswese.

G. C. THERON,  
Saamroeper

13 Februarie, 1967.

#### JAARVERSLAG OOR DIE WERKSAMHEDE VAN DIE DEPARTEMENT VIR FISIKA EN ELEKTROGNIESE INGENIEURSWESE VAN DIE S.A.B.S.

Ko-ordinerende Verteenwoordiger: G. C. Theron.

##### 1. Verpligte veiligheidspeesifikasies:

Wysiging No. 1 aan die standaard spesifikasies vir elektriese toerusting is op 22 April 1966 in Staatskoerant No. 1430 gepubliseer.

Die voorgestelde wysiging No. 2 was vrygestel op 6 Januarie 1967 in Staatskoerant No. 1628. Die buro het min probleme ondervind met die administrasie van die verpligte spesifikasies sedert dit op 3 Julie 1965 van krag geword het, en het die handel en nywerhede baie hulpvaardig gevind.

Daar is gevind dat sekere ongerymdhede voorkom deurdat sekere bybehore en buigbare koorde (skedules 1, 4, 6, 9 en 10) nie beperk tot die apparaat in die skedules gelys is nie, maar nog moet voldoen al word dit verkoop as bybehore van enige toestel selfs al verskyn dit nie in die skedules nie. Die volgende voorbeeld sal die saak verduidelik:

listed in the schedules, but must still comply when sold as accessories of any piece of equipment not listed in the schedules. The following examples will illustrate the point:

As the regulations stand at present it would be permissible for a washing machine to be fitted with a two-core flexible cord rated at say 3 amps., and a 5 amp. switch, although the machine needs to be fitted with say a 10 amp. 3-core flexible cord and a 10 amp. switch. Provided that the flexible cord and switch fitted to the machine complied with Schedules 4 and 1, the manufacturer could claim that his washing machine "complies with Government Safety Regulations". It often happens that appliances which are brought to the Bureau for checking, fall within the scope of the compulsory specifications only with respect to the flexible cord. If the cord complies with the relevant requirements of Schedule 4, the appliance again "complies with Government Safety Regulations", however unsafe it might be or however wrong the type of cord for the particular application.

In order to rectify this state of affairs it would be necessary to declare compulsory the following safety specifications which have already been drawn up, viz.

- SABS SV 108 Domestic electric washing machines  
113 Electric toasters  
114 Electric irons  
and 115 Electric soldering irons.

## 2. ELECTROTECHNICAL NOMENCLATURE

Your association is represented on this committee by Mr. J. von Ahlften. Twenty meetings were held during this period and the following documents finalized:

- Group 08 : Electro-acoustics  
Group 20 : Scientific and Industrial measuring instruments  
Group 25 : Generation, Transmission and Distribution of Electrical Energy.

The final printed version of Group 05 — Fundamental terms, became available during July 1965.

## 3. PROGRESS REPORT

### Code of Practice for the Lighting of Streets and Highways:

Part 1 of this Code elicited 49 typed folio sheets of comments which necessitated eleven meetings of the technical committee to finalize the document. It is now being translated before submission to the Council of the SABS for approval. Good progress is being maintained with Part 2 of the Code which should shortly be ready for comment.

Representative: A. F. Turnbull.

### Ballasts for Fluorescent Lamps:

This specification is past the comment stage and two meetings have been held to discuss comments received. It is anticipated that a further two meetings will be required to finalize the comments.

Representative: N. P. Adams.

Soos die regulasies nou lees sal dit heeltemal toelaatbaar wees om 'n tweear buigbare koord van sê 3 ampere dravermoe en 'n 5 ampere skakelaar te gebruik op 'n wasmasjien wat eintlik 'n 10 ampere, 3-aar buigbare koord en 10 ampere skakelaar behoort aan te hê.

Indien die buigbare koord en skakelaar aan die masjien aan die vereistes van skedules 4 en 1 voldoen, kan die vervaardiger beweer dat sy wasmasjien "voldoen aan die vereistes van die amptelike veiligheidsregulasies". Dit gebeur dikwels dat toestelle wat na die buro gebring word vir kontrole, net ten opsigte van die buigbare koord aan die vereistes van die verpligte spesifikasies voldoen. As die koord voldoen aan die betrokke vereistes van skedule 4, dan weer "voldoen die toestel aan die staat se veiligheidsregulasies" afgesien van hoe gevaarlik dit mag wees of hoe verkeerd dit mag wees om die tipe koord so aan te wend.

Ten einde die posisie reg te stel sal dit nodig wees om die volgende veiligheidspeisifikasies wat reeds saamgestel is, verpligtend te maak:-

- SABS SV 108 : Huishoudelike wasmasjiene;  
113 : Elektriese roosters;  
114 : Elektriese strykysters;  
en 115 : Elektriese soldeerysters.

## 2. ELEKTROTEGNIESE NOMENKLATUUR:

Die vereniging word op hierdie komitee deur Mnr. J. von Ahlften verteenwoordig. Twintig vergaderings was gereende hierdie tydperk gehou en die volgende dokumente is voltooi:-

- Groep 08 : Elektro-akoestiek.  
Groep 20 : Wetenskaplike en nywerheidsmeetinstrumente.  
Groep 25 : Ontwikkeling, transmissie en verspreiding van elektriese energie.

Die finale persuitgawe van groep 05 — basiese terme, het in Julie 1965 die lig gesien.

## 3. VORDERINGSVERSLAG:

### Gebruikskode vir die verligting van strate en hoofwêe:

Die kommentaar ontvang op deel 1 van die kode het 49 getikte folio-velle getel en elf vergaderings van die tegniese komitee moes gehou word om die dokument te finaliseer. Dit word nou vertaal voordat dit aan die raad van die S.A.B.S. vir goedkeuring voorgelê word. Goëie vordering word gemaak met deel 2 van die kode wat binnekort vir kommentaar gereed sal wees.

Vertenwoordiger: A. F. Turnbull.

### Ballas vir fluorensielampe:

Hierdie spesifikasie is reeds verby die kommentaar-stadium en twee vergaderings is reeds gehou om die kommentaar soos ontvang te bespreek. Daar word verwag dat nog twee vergaderings nodig sal wees om die kommentaar af te handel.

Vertenwoordiger: N. P. Adams

**Code of Practice for the Classification of the Choice of Electrical Equipment in Dangerous Locations:**

Four meetings, two by Working Groups and two by the main committee, were held and the document is now being prepared for comment.

Representative: L. Fletcher.

**Specification for Non-Sparking Electrical Equipment for use in Class 1, Division 2 Locations:**

To date two meetings were held, a number of points concerning the Working Groups being dealt with by letter and telephone. As a result of the second meeting a number of problems were referred to the Working Groups. Because of its complex nature at least one further Committee Meeting will be required before the document can be circulated for comment.

Representative: J. J. Barrie.

**SABS 158 — Electric Kettles and Similar Electrical Appliances for Heating Liquids:**

**SABS 160 — Electric Air Heaters:**

**SABS 784 — Bushbar Trunking:**

**SABS SV 134 — Safety Specification for Domestic Electric Refrigerators and Food Freezers.**

**SABS 093 — Code of Practice for the Testing of Domestic Electric Refrigerators and Food Freezers:**

These specifications and Code of Practice were all approved by the Council of the SABS on the 23rd August, 1965.

**SABS 153 — Electric Stoves and Hotplates:**

**SABS 157 — Electric Toasters:**

**SABS 159 — Electric Irons:**

These specifications were approved by the Council of the SABS on the 22nd August, 1966.

**Meter Cabinets:**

The proposed Specification has been issued for comment.

Representative: P. J. Botes.

**SABS 97 — Paper Insulated Cables for General Purposes.**

The revision of this Specification is being translated prior to sending it out for comments.

Representative: G. C. Theron.

**Standard Test Methods for Electric Cables and Flexible Cords:**

This Code of Practice is now being edited before submitting same to the Council of the SABS for approval.

Representative: G. C. Theron.

**Induction Motors:**

Two meetings of the committee were held during the past year. It is anticipated that the draft for comment will be ready in the near future.

Representative: P. J. Botes.

**Electrical Arc Welding Transformers:**

One meeting of the committee was held.

Representative: J. K. von Ahlfen.

**Gebruikskode vir die klassifikasie en keuse van elektriese toerusting in gevaarlike plekke:**

Vier vergaderings, twee deur die werkende groep en twee deur die hoofkomitee, is gehou en die dokument word nou voorberei vir die inwag van kommentaar.

Verteenwoordiger: L. Fletcher.

**Spesifikasie vir vonklose elektriese toerusting vir gebruik in klas 1 afdeling 2 plekke:**

Dusver is twee vergaderings gehou en 'n aantal punte wat die werkende groepe betref is per brief en telefoon afgehandel. Voortvloeiende vanaf die tweede vergadering is 'n aantal probleme na die werkende groepe verwys. Weens die ingewikkelde aard van die aangeleentheid sal minstens nog een vergadering van die komitee nodig wees voordat die dokument gereed sal wees om vir kommentaar uitgestuur te word.

Verteenwoordiger: J. J. Barrie.

**SABS 158 — Elektriese ketels en soortgelyke elektriese toestelle vir die verhitting van vloeistowwe:**

**SABS 160 — Elektriese lugverwarmers:**

**SABS 784 — Stanggeleierskagte:**

**SABS SV 134 — Veiligheidspeksifikasie vir huishoudelike elektriese yskaste en kosbevroersers:**

Hierdie spesifikasies en gebruikskodes is almal deur die raad van die S.A.B.S. op 23 Augustus 1965 goedgekeur.

**SABS 153 — Elektriese Stowe en warmplate:**

**SABS 157 — Elektriese broodroosters:**

**SABS 159 — Elektriese strykkysters:**

Hierdie spesifikasies is op 22 Augustus 1966 deur die raad van die S.A.B.S. goedgekeur.

**Meterkaste:**

Die voorgestelde spesifikasie is vir kommentaar vrygestel.

Verteenwoordiger: P. J. Botes.

**SABS 97 — Papier geïsoleerde kabel vir algemene doeleindes:**

Die hersiene spesifikasie word tans vertaal voordat dit vir kommentaar uitgestuur word.

Verteenwoordiger: G. C. Theron.

**Standaard toetsmetodes vir elektriese kables en buigbare koorde:**

Hierdie gebruikskode word nou gereedigeer voordat dit aan die raad van die S.A.B.S. vir goedkeuring voorgelê word.

Verteenwoordiger: G. C. Theron.

**Induksie Motors:**

Twee vergaderings van die komitee is gedurende die jaar gehou. Daar word verwag dat die konsep binnekort vir kommentaar gereed sal wees.

Verteenwoordiger: P. J. Botes.

**Elektriese boog-sweistransformators:**

Een vergadering van die komitee is gehou.

Verteenwoordiger: J. K. von Ahlfen.

#### SABS 780 — Distribution Transformers:

This Specification was approved by the Council of the SABS on the 5th December, 1966. This specification should have a great bearing on reduced cost of manufacture and streamlined inspection and tests since transformers bearing the mark would be quality controlled, tested and inspected to the Bureau's satisfaction.

Representative: F. L. Knobel.

#### SABS 833 — High and Low Voltage Bushings, and

#### SABS 834 — Standard Bushing Insulators:

These Specifications were also approved by the Council of the SABS on the 5th December, 1966. They should assist in improving economics and interchangeability as a number of standard bushings with hardware for use on low and high voltage up to 33 kV are detailed.

Representative: C. Lombard.

#### SABS 177 — High Voltage Porcelain and Glass Line Insulators:

This Specification is being revised in order to bring it into line with I.E.C. testing procedures and standard ratings.

Representative: F. J. Sulter.

#### Fittings for Overhead Power Lines:

In order to standardize the fittings used on overhead power lines a specification is being prepared in two stages, viz.:

Part A — Non-current carrying fittings,

Part B — Current carrying fittings.

Representative: E. L. Smith.

#### Cable End Boxes for Distribution Transformers:

Work on this project is proceeding.

Representative: F. L. Knobel.

#### 4. NEW PROJECTS

##### 4.(1) SABS 176 — Porcelain Cleats, Bobbins and Leading-in Tubes:

The Council of the SABS approved the revision of this specification in order to include commodities made of materials other than ceramic.

##### 4.(2) Specification for Insulation Levels for Electrical Equipment:

A specification is to be drawn up in order to clarify problems connected with insulation at altitudes above 1000 m. (3,300 ft.). In conjunction with this specification a Code of Practice to lay down acceptable impulse voltage testing procedures will be prepared.

##### 4.(3) CKS Specifications for Battery Chargers and for Battery terminals and Connectors:

Work on these Specifications has been commenced.

#### C.S.I.R. REPORT: NATIONAL RESEARCH INSTITUTE OF MATHEMATICAL SCIENCES ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING

A.M.E.U. Representative: G. C. THERON

This committee met once during 1966 and reviewed the work of the electrical engineering division as well as the

#### SABS 780 — Distribusie transformators:

Hierdie spesifikasie is deur die raad van die S.A.B.S. op 5 Desember 1966 goedgekeur. Hierdie spesifikasie behoort baie by te dra om die vervaardigingskoste te verminder en ondersoek en toets te vereenvoudig aangesien transformators wat die merk dra die buro sal moet bevredig ten opsigte van kwaliteit, toets en inspeksies.

Verteenwoordiger: F. L. Knobel.

#### SABS 833 — Hoog- en laagspanningdeurvoerings:

#### SABS 834 — Standaard deurvoering-isolators:

Hierdie spesifikasie is ook op 5 Desember 1966 deur die raad van die S.A.B.S. goedgekeur. Dit behoort by te dra om ekonomiese en uitwisselbaarheid te bevorder aangesien 'n aantal standaard deurvoerings en toebehore vir gebruik op laag- en hoogspanning tot 33 K.V. aangegee word.

Verteenwoordiger: C. Lombard.

#### SABS 177 — Hoogspanning porselein en glas lynisolators:

Hierdie spesifikasie word hersien ten einde dit by I.E.C. toetsvoorskrifte en standaard groottes aan te pas.

Verteenwoordiger: F. J. Sulter.

#### Toebehore vir bogronde kraglyne:

Ten einde die toebehore vir gebruik op bogronde kraglyne te standaardiseer word 'n spesifikasie in twee dele voorberei n.l.

Deel A : nie-stroomdraende toebehore;

Deel B : stroomdraende toebehore.

Verteenwoordiger: E. L. Smith.

#### Kabel-entkaste vir distribusie transformators:

Werk op hierdie spesifikasie gaan nog voort.

Verteenwoordiger: F. L. Knobel.

#### 4. NUWE PROEKTJE

##### 4.(1) SABS 176 — porselein klampe, tolle en invoerbuis:

Die raad van die S.A.B.S. het die hersiening van die spesifikasie om voorsiening te maak vir die gebruik van ander materiale as net keramiek, goedgekeur.

##### 4.(2) Spesifikasie vir isolasiepeile vir elektriese toerusting:

'n Spesifikasie gaan opgestel word ten einde die probleme verbode aan isolering by hoogtes bo 1,000 m. (3,300 vt.) op te klaar. Om aan te pas by die spesifikasie sal 'n gebruikskode opgestel word om aanvaarbare prosedures vir die doen van impuls-spanningstoets vas te lê.

##### 4.(3) CKS Spesifikasies vir batterylaaiers en batteryklemme en verbindings:

Daar is reeds met die werk aan hierdie spesifikasies 'n aanvang gemaak.

#### W.N.N.R. VERSLAG: NASIONALE NAVORSINGSINSTITUUT VIR WISKUNDIGE WETENSAPPE ADVISERENDE KOMITEE VIR ELEKTROTEGNIESE INGENIEURSWESE

V.M.E.O. Verteenwoordiger: G. C. THERON

Hierdie komitee het eenkeer gedurende 1966 vergader om die werksaamheid van die afdeling vir elektrotegniese in-

planning of future projects. The work of the institute is also hampered by a shortage of staff and some projects had to be postponed.

A paper is being read at this convention to review some of the electrical engineering work of the C.S.I.R. of interest to local authorities.

#### REPORT OF THE HOT-DIP GALVANISED ZINC COATING SUB-COMMITTEE

A meeting of the South African Bureau of Standards committee was held on 21st February 1967 when zinc coatings on steel wire used for electrical purposes and zinc coatings on steel sheet used for cladding and buildings was discussed and the representatives of the users, being the municipalities, Escom, Railways and the Post Office, pressed for maximum practicable coatings. A further meeting to finalise this aspect is to be held.

P. A. GILES,  
Representative.

6th March, 1967.

#### REPORT OF THE LEVEL PRICE TENDERING SUB-COMMITTEE

The questionnaire drawn up by the Board of Trade and Industries in regard to individual and collective resale price maintenance, i.e., level price tendering, was completed by the sub-committee and sent to the Board in June 1965.

Subsequently, the Board has desired the attendance of a representative of the Association at a meeting on 5th April 1967 to discuss issues arising from the Association's representations. The convener will attend this meeting and further developments are awaited.

P. A. GILES,  
Convener.

6th March, 1967.

#### REPORT OF RIGHTS OF SUPPLY AND GENERATION SUB-COMMITTEE

Following the report of this sub-committee to the Technical Meeting at Bloemfontein, the sub-committee met on the 3rd May, 1966, when the subject was considered and the following conclusions were drawn as the views of the Association:-

- (a) Municipalities should be permitted to take over incorporated areas on agreed terms. The right should

genieurswese en die beplanning van toekomstige projekte in oëskop te neem. Die werk van die instituut word deur 'n tekort aan personeel gekortwiek en enkele projekte moes uitgestel word.

'n Referaat word by hierdie konvensie aangebied om 'n oorsig te gee van die werksaamhede van die W.N.N.R. op die gebied van elektrotegniese ingenieurswese van belang vir plaaslike besture.

#### VERSLAG VAN DIE SUBKOMITEE INSAKE WARMDOMPEL-GEGALVANISEERDE SINKLAE

'n Vergadering van die Komitee van die Suid-Afrikaanse Buro vir Standaarde is op 21 Februarie 1967 gehou, by welke geleentheid die versinking van staaldraad wat vir elektriese doeleindes gebruik word en die sinkbedekking van staalplate wat vir bou- en omhuldoeleindes gebruik word, bespreek is. By hierdie vergadering het die gebruikers, naamlik die munisipaliteite, EVKOM, die Spoorwee en die Poskantoor, aangedring op die maksimum-bedeeking wat prakties moontlik is. 'n Verdere vergadering sal gehou word om hierdie aspekte te finaliseer.

P. A. GILES,  
Verteenwoordiger.

6 Maart 1967.

#### VERSLAG VAN DIE SUBKOMITEE INSAKE DIE AANBIEDING VAN GELYKE PRYSE

Die vraelys wat deur die Raad van Handel en Nywerheid opgestel is in verband met die individuele en gesamentlike handhawing van herverkooppryse, d.w.s. die aanbidding van gelyke pryse, is in June 1965 deur die subkomitee voltooi en aan die Raad gestuur.

Die Vereniging is hierop versoek om 'n verteenwoordiger te stuur na 'n vergadering van die Raad wat op 5 April 1967 gehou sal word om sake wat uit die Vereniging se vertoë voorspruit, te bespreek. Die sameroeper sal hierdie vergadering bywoon en verdere verwikkelinge word afgewag.

P. A. GILES,  
Sameroeper.

6 Maart 1967.

#### VERSLAG VAN DIE SUB-KOMITEE INSAKE VERSKAFFINGSREGTE EN ONTWIKKELING

Na aanleiding van die verslag van hierdie Sub-komitee aan die Tegniese Vergadering te Bloemfontein, het die Sub-komitee weer op 3 Mei 1966 byeen gekom om die saak te oorweeg en die onderstaande gevolgtrekkings is as die Vereniging se sienswyses te boek gestel:-

- (a) Munisipaliteite behoort toegelaat te word om ingelyfde gebiede oor te neem op voorwaardes waarvoor

also be accorded to the Municipality to take over Escom's licence and equipment on agreed terms.

- (b) Where a Municipality infringes into an Escom licensed area, unless Escom provides that Municipality with bulk supply, the means must be devised for allowing a self generating authority to take over Escom's licence for that area.
- (c) An element of stability should be accorded to Escom's tariff and upward revisions of the tariff should be held over for five year periods, utilising tariff stabilisation funds.
- (d) The principle of taking profits for the relief of rates should be accorded to Local Authorities.
- (e) To meet very rapidly changing modern conditions it should be acknowledged as necessary for local authorities to subsidise themselves from their trading undertakings.
- (f) The information submitted to the Administrator by Escom when considering new schemes should be submitted to the affected Municipalities before a decision is taken.
- (g) In view of the rapidly changing circumstances in which Local Authorities find themselves with tremendous liabilities, particularly resulting from motor traffic, expressways and ancillary services, it is necessary to conceive town planning on an autonomous basis, with Municipalities responsible for providing the services and being possessed of sufficient sources of revenue to do so.

The conclusions set out in (a) to (g) above were supported by the United Municipal Executive at its meeting on 23rd and 24th August 1966 and the Association was requested to proceed with the drafting of a full memorandum which should include the following additional points raised at the United Municipal Executive meeting:-

- (a) The gradual development of Escom into a monopolistic concern for the generation of electricity in spite of anti-monopolistic legislation (Act No. 24 of 1955). In this process the rights of local authorities are being assailed and their plans for the extension of their power generating plants are delayed.
- (b) The inequity of Escom acting as advisers to the Provincial Administrations on which heavy capital commitments have been incurred, if in the end their power undertakings are displaced by Escom, with special reference to the Orange and Kunene Rivers hydro-electric projects.

ooreengekom kan word. Die Munisipaliteit behoort ook die reg te hê om Evkom se lisensie en toerusting op ooreengekome voorwaardes oor te neem.

- (b) In gevalle waar 'n munisipale gebied oorskry op 'n gebied ten opsigte waarvan EVKOM 'n lisensie het en, tensy daardie Munisipaliteit 'n grootmaat — voorraad vanaf EVKOM kry, behoort die middel gevind te word om 'n plaaslike owerheid wat sy eie krag ontwikkel, toe te laat om EVKOM se lisensie ten opsigte van daardie gebied oor te neem.
- (c) Evkom se tariewe behoort met 'n element van vastigheid beklee te word, en tariefherienings wat verhogings meebring, behoort slegs elke vyf jaar oorweeg te word, terwyl tarief-stabilisasiefondse in die tussentye aangewend behoort te word.
- (d) Die beginsel daarvan om winste ter verligting van belastinge aan te wend, behoort slegs ten opsigte van plaaslike owerhede te geld.
- (e) Daar behoort erken te word dat dit, weens snel-veranderende moderne toestande, vir plaaslike owerhede nodig is om hulself met winste uit hul handels-ondernemings te subsidiëer.
- (f) Die inligting deur Evkom aan die Administrateur verstrekk wanneer nuwe skemas oorweeg word, behoort aan die Munisipaliteite wat daarby betrokke is, voorgeleg te word voordat 'n beslissing gevel word.
- (g) Met die oog op die snel-veranderende omstandighede waarin plaaslike besture hulself bevind en die gewelddige verpligtinge wat dit meebring, veral wat betref motorverkeer, snelwee en dienste wat daarmee saamval, is dit nodig dat stadsbeplanning op 'n outonome grondslag aangepak word, sodat Munisipaliteite die verantwoordelikheid vir die verskaffing van die dienste sal aanvaar en terselfdertyd genoegsame bronne van inkomste sal hê om hulle in staat te stel om dit te doen.

Die gevolgtrekkinge in (a) tot (g) hierbo uiteengesit, is op sy vergadering van 23 en 24 Augustus 1966 deur die Verenigde Munisipale Bestuur ondersteun, en hierdie Vereniging is versoek om voort te gaan met die opstelling van 'n omvattende memorandum, waarin die volgende bykomende punte wat by die vergadering van die Verenigde Munisipale Bestuur geopper is, vervat is:-

- (a) Die geleidelike ontwikkeling van Evkom tot 'n monopolistiese organisasie vir die opwekking van elektrisiteit, tensypte van wetgewing ter besnyding van monopolistiese toestande (Wet No. 24 van 1955). In hierdie proses word die bevoegdheid van plaaslike besture aangetas en hulle planne ter uitbreiding van hul krag-ontwikkelingsinstallasies word vertraag.
- (b) Die onregverdigheid daarvan dat Evkom ootree as raadgevers vir die Provinsiale Administrasies, deur wie swaar kapitale verpligtinge aangegaan is, indien laasgenoemde se kragverskaffingsondernemings uitsluitend deur Evkom vervang word. In hierdie ver-



A sub-committee meeting on 25th November 1966 adopted the terms of a full memorandum which was dated 6th December 1966, embodying the above ten points. It was submitted to the United Municipal Executive for consideration at its meeting in February 1967 and at this meeting it appears that the United Municipal Executive appointed a sub-committee to redraft the memorandum prior to submission to the Minister.

P. A. GILES,

6th March, 1967.

Convener.

### REPORT OF THE

#### S.A. NATIONAL COMMITTEE OF THE INTERNATIONAL ELECTRO-TECHNICAL COMMISSION

Apart from normal participation in all the active committees of the International Electro-technical Commission, it may be reported that the annual general meeting of the I.E.C. held in Tel Aviv from 3rd to 14th October, 1966, was attended by five South African delegates, two of whom were from Industry. The industries concerned were the Electrical Accessories industry and the Winding Wire industry. There were approximately 500 delegates and the meeting covered 23 technical committees.

Of particular interest was the work on electrical appliances. Because of the experience gained by the application of the Standardisation Mark Scheme in the Republic of South Africa, the South African delegation was able to contribute much useful information.

Work on winding wires also deserves special mention since we have several firms concerned with the manufacture of this strategic commodity. The work on insulation should also be singled out particularly as it stressed the fact that more attention should be paid to the specification and testing of this basic electrical material.

A far reaching decision was made when it was agreed to divide the study of insulation into three divisions, viz:-

- (a) Insulating Material.
- (b) Insulating Systems.
- (c) The insulation of Equipment.

It was also decided to form a new committee concerned with safety requirements for electrical appliances and equipment. This is of great importance in South Africa in view of the compulsory specifications we have in this regard.

D. J. HUGO,

15th February, 1967.

Representative.

band word spesiaal na die hidro-elektriese projekte van die Oranje- en Kuneneriviere verwys.

By 'n sub-komiteevergadering op 25 November 1966 is die bewoording aanvaar van 'n omvattende memorandum, gedateer 6 Desember 1966, waarin die bogenoemde tien punte vervat is. Hierdie memorandum is aan die Verenigde Munisipale Bestuur 'n sub-komitee aangewys het om die memorandum te herformuleer voordat dit aan die Minister voorgelê word.

P. A. GILES,

6 Maart, 1967.

Sameroeper.

### VERSLAG VAN DIE

#### S.A. NASIONALE KOMITEE VAN DIE INTERNASIONALE ELEKTROTEGNIËSE KOMMISSIE

Afgesien van normale deelname in al die aktiewe komitees van die Internasionale Elektrotegniese Kommissie, kan ook gerapporteer word dat die Jaarlikse Algemene Vergadering van die I.E.K. wat van 3 tot 14 Oktober 1966 in Tel Aviv gehou is, bygewoon is deur vyf Suid-Afrikaanse afgevaardigdes, van wie twee uit die industriële sektor was. Die betrokke industriële was die Elektriese onderdele-industrie en die Wikkeling-draadindustrie. Daar was in totaal sowat 500 afgevaardigdes en 23 afsonderlike tegniese komitees.

Van besondere belang was die werk op elektriese toestelle. As gevolg van die ondervinding verkry deur die toepassing van die Standaardmerkskema in die Republiek van Suid-Afrika, kon die Suid-Afrikaanse afvaardiging baie bruikbare inligting verskaf.

Die werk in verband met wikkeldraad verdien ook spesiale aandag omdat ons verskeie firmas het wat hierdie belangrike handelsartikel vervaardig. Die vooruitgang op die gebied van isolasiemateriaal gerverdig ook spesiale vermelding veral omdat gevoel is dat meer aandag aan die spesifikasie en toets van hierdie basiese elektriese onderdeel gesken behoort te word.

'n Vereikende besluit is geneem toe daar besluit is om die bestudering van isolasiemateriaal in drie groepe te verdeel. nl.:-

- (a) Isolasiemateriaal.
- (b) Isoleerstelsels.
- (c) Die Isolasië van Apparaat.

Daar is ook besluit om 'n nuwe komitee, belas met die veiligheidsvereistes vir elektriese toestelle en apparaat, in die lewe te roep. Omdat Suid-Afrika verpligte spesifikasies ten opsigte van veiligheid het, is die stigting van die bogenoemde komitee vir ons van besondere belang.

D. J. HUGO,

15 Februarie, 1967.

Verteenwoordiger

## ANNUAL REPORT

### S.A.I.E.E. COMMITTEE TO REVISE THE CODE OF PRACTICE FOR OVERHEAD LINES FOR CONDITIONS PREVAILING IN SOUTH AFRICA

As has previously been reported, the Committee has completed its work and the revised code has been published.

Copies can be obtained from the Secretary, The S.A. Institute of Electrical Engineers, P.O. Box 5907, Johannesburg.

C. LOMBARD,  
Representative.

### ANNUAL REPORT OF THE RECOMMENDATIONS COMMITTEE FOR NEW ELECTRICAL COMMODITIES

Two meetings were held during the year under review and A.M.E.U. members were advised of all recommendations through the medium of the News Bulletin.

Compared with the year before, there has been a marked increase in the number of applications received. All of those which were considered to fall within the scope of the Committee's work have been finalised.

In view of the fact that Consulting Engineers are not represented on the Committee, the S.A. Association of Consulting Engineers has been invited to nominate a representative and alternate to serve on it but have not yet responded to this invitation.

Our thanks are due to the representatives of the S.A. Bureau of Standards, the Electricity Supply Commission, the S.A.I.E.E. Wiring Regulations Committee, the Electrical Contractors Association of South Africa, the Johannesburg City Council and the Electrical Engineering and Allied Industries Association for their generous and valuable assistance and service on the Committee. We also thank the S.A. Bureau of Standards for its co-operation in carrying out tests on commodities where necessary.

C. LOMBARD,  
Convener.

## ANNUAL REPORT

### ELECTRICAL WIREMEN'S REGISTRATION BOARD

The Board was constituted as follows during 1966:

Chairman: Mr. J. G. Wannenburg  
Members: Mr. J. M. Fraser  
Mr. F. Leemans  
Mr. T. Gregg  
Mr. C. Lombard  
Mr. J. J. Gerber

Eleven ordinary meetings were held during the year and the applications of 709 persons applying for registration were

## JAARVERSLAG

### S.A.I.E.E.-KOMITEE BELAS MET DIE HERSIENING VAN DIE GEBRUIKSKODE VIR BOGRONDSE LYNNE VIR TOESTANDE SOOS IN SUID-AFRIKA AANGETREF

Soos vantevore gerapporteer het die Komitee sy opdrag afgehandel en die hersiene gebruikskode is gepubliseer.

Afskrifte is verkrygbaar van die Sekretaris, Die S.A. Instituut van Elektrotegniese Ingenieurs, Posbus 5907, Johannesburg.

C. LOMBARD,  
Verteenwoordiger.

### JAARSVERSLAG VAN DIE KOMITEE BELAS MET AANBEVELINGS T.O.V. NUWE ELEKTRIESE HANDELSARTIKELS

Twee vergaderings is gedurende die onderhawige jaar gehou en alle aanbevelings is deur middel van die Nuisbulletin aan V.M.E.O. lede oorgedra.

Vergeleke by die vorige jaar, was daar 'n merkbare toename in die aantal aansoeke ontvang. Alle aansoeke wat beskou was om binne die bestek van die Komitee se werksaamhede te ressorteer is afgehandel.

Aangesien Raadgewende Ingenieurs nie verteenwoordiging in die Komitee het nie is 'n uitnodiging aan die S.A. Vereniging van Raadgewende Ingenieurs gerig om 'n verteenwoordiger en 'n plaasvanger te benoem om in die Komitee te dien maar hulle het sover geen antwoord gegee nie.

Ons is dank verskuldig aan die verteenwoordigers van die S.A. Buro vir Standaarde, die Elektrisiteitsvoorsieningskommissie, die S.A.I.E.E. Bedravingsregulasieskomitee, die Elektrotegniese Aannemersvereniging van Suid-Afrika, die Johannesburgse Stadsraad en die Elektrotegniese Ingenieurswese en Geallieerde Nywerhede Vereniging vir hul gulle en waardevolle hulp en diens in die Komitee. Ons dank ook aan die S.A. Buro vir Standaarde vir hulle samewerking met die toets van toerusting waar nodig.

C. LOMBARD,  
Saamroeper.

## JAARVERSLAG

### REGISTRASIERAAD VIR ELEKTROTEGNIESE DRAADWERKERS

Die Raad was soos volg saamgestel vir 1966:

Voorsitter: Mnr. J. G. Wannenburg  
Lede: Mnr. J. M. Fraser  
Mnr. F. Leemans  
Mnr. T. Gregg  
Mnr. C. Lombard  
Mnr. J. J. Gerber

Daar is elf gewone vergaderings gedurende die jaar gehou en 709 persone se aansoeke om registrasie is oorweeg; daarvan

considered of which 679 were accepted as candidates for the prescribed examinations. The number of provisional registration certificates granted or renewed totalled 791.

Five written examinations were conducted at the 29 examination centres in the Republic during the year, the total number of candidates involved being 849.

There were also 14 practical examinations at the eight principal centres during the year and 206 of the 563 candidates entered were successful.

Several oral examinations were arranged for persons who, for various reasons, were unable to undergo the written examination.

The number of registration certificates issued during the year totalled 333 bringing the total issued since 1940 to 9554.

Bantu are now applying in increasing numbers for registration and the Central Organisation for Trade Testing of the Department of Education, Arts and Science is making special arrangements to enable them to undergo the examination.

Facilities have in the past been provided to enable immigrants who are not sufficiently proficient in one of the official languages, to write the examination in their native language. Arrangements have now also been made to set examination papers for immigrants in their native language and the first examination on these lines will be held during April, 1967. For understandable reasons, a minimum number of six candidates in any language group must apply for this facility before it can be made available.

Only one Advisory Committee has so far been established namely at Durban, and the work done by this Committee has been of considerable assistance to the Board.

Several amendments to the Electrical Wiremen and Contractors Act are under consideration, but these have not yet been finalised. All parties concerned will, in due course, be advised of the proposed amendments and will be given an opportunity to submit their comments.

The lack of uniformity in the wiring regulations in force and applied by the various supply authorities in the Republic is viewed with considerable concern by the Board, as all examinations for wiremen are based on the latest edition of the Standard Regulations for the Wiring of Premises. Even more unsatisfactory is the fact that some supply authorities have not formally adopted any wiring regulations which means that there is not set standard for the purpose of inspecting and testing wiring installations.

In conclusion, I wish to thank the Board for making the statistics quoted available to me for inclusion in this Report.

C. LOMBARD,  
Representative.

is 679 aangeneem as kandidate vir die voorgeskrewe eksamens. 'n Totaal van 791 voorlopige registrasiesertifikate is goedgekeur of hernu.

Gedurende die jaar is vyf skriftelike eksamens in die 29 eksamen-sentrums in die Republiek afgeneem. Altesaam 849 kandidate was daarby betrokke.

Daar was ook 14 praktiese eksamens in die 8 vernaamste sentrums gedurende die jaar en 206 uit die 563 ingeskrewe kandidate was suksesvol.

Reëlings is getref vir die aflê van mondelinge eksamens waar persone, wat om verskeie redes, nie in staat was om die skriftelike eksamens af te lê nie.

'n Totaal van 333 registrasiesertifikate is gedurende die jaar uitgereik en daarmee kom die totaal sedert 1940 nou op 9554 te staan.

Bantoes doen ook in toenemende getalle aansoek om registrasie en die Sentrale Organisasie belas met vakoetse in die Departement van Onderwys, Kuns en Wetenskap maak spesiale reëlings om dit vir hulle moontlik te maak om die eksamens af te lê.

In die verlede is fasiliteite daargestel om immigrante wat nie voldoende bedrewe in een van die amptelike landstale is nie, in staat te stel om die eksamens in hulle eie taal af te lê. Reëlings is nou ook getref vir die opstel van eksamenverreëls in immigrante se eie taal en die eerste eksamen op hierdie grondslag sal in April 1967 aangebied word. Om verstaanbare redes sal daar 'n minimum van ses kandidate in 'n taalgroep moet wees om hierdie fasiliteit beskikbaar te stel.

Slegs een Advieskomitee het sover tot stand gekom, naamlik in Durban. Die werk deur hierdie Komitee gedoen was van aansienlike waarde vir die Raad.

Verskeie wysings aan die Wet op Elektrotegniese Draadwerkers en Aannemers word tans oorweeg, maar is nog nie afgehandel nie. Alle belanghebbende instansies sal mettertyd kennis kry van die voorgestelde wysings en ook die geleentheid om kommentaar daarop te lewer.

Die gebrek aan eenvormigheid in die bedravingsregulasies in werking en toegepas deur die verskeie voorsieningsondernemings in die Republiek word met 'n mate van besorgdheid deur die Raad beskou aangesien alle eksamens vir draadwerkers volgens die jongste uitgawes van die Standaard Regulasies vir die Bedrading van Persele opgestel word. Nog meer onbevredigend is die feit dat sommige voorsieningsowerhede formeel nog geen bedravingsregulasies aangeneem het nie, m.a.w. daar is geen voorgeskrewe standaard om bedravingsaanlegte te inspekteer of toets nie.

Ten besluite wil ek graag die Raad bedank vir die skikbaarstelling van die statistieke syfers vir gebruik in hierdie verslag.

C. LOMBARD,  
Verteenwoordiger.

## REPORT ON THE STANDARD REGULATIONS FOR THE WIRING OF PREMISES

At its meeting on 4th August 1966, the Committee dealt with a number of proposals received from its Cape-Western and Natal regional sub-committees, the Association of Municipal Undertakings, the South African Bureau of Standards, the Department of Labour, consultants, manufacturers and arising from general correspondence. It was resolved to issue 1966 amendments to the regulations following the 1963 amendments and printing, translation and issue was completed by February 1967.

The more important amendments related to the positioning and earthing of socket outlets, and fixed washing machines, dishwashers, stoves, water heaters and garbage disposal units and the alternatives of isolating transformers or earth leakage devices were specified. These amendments permitted the strict application of the regulations to all installations (including hairdressing saloons, laundries and laboratories) constructed or altered subsequent to 1st January 1967.

At the August 1966 meeting of the Committee, the recently-issued 14th Edition of the Wiring Regulations of the London Institution of Electrical Engineers was not yet available for study.

Up to the end of 1966 several thousand copies of the Institute's Wiring Regulations had been sold since the first publication in September 1940, and demand is heavy for the 1966 amended edition. Separate amendments running to three printed pages are available for alteration of the 1963 edition.

R. LEISHMAN, Chairman

## REPORT OF SOUTH AFRICAN ELECTROLYTIC CORROSION COMMITTEE

Since no report was submitted at the 1966 Bloemfontein one day technical meeting, this report covers the two years since the May 1965 Port Elizabeth Convention.

The tenth and final meeting of the Witwatersrand Electrolysis Main Committee was held in Johannesburg on 3rd June 1965. The main business was to discuss a draft constitution covering a re-organisation of the Main and Field Committees controlling the Republic's electrolysis problems and expanding the field of representation. This was necessitated by the large extensions to railway electrification, pipelines for water, gas and oil and prospective country-wide power transmission lines.

The inaugural meeting of the South African Electrolytic Corrosion Committee was held in Johannesburg on 24th May 1966, for the formal adoption of the draft constitution and the formation of Regional Field Committees at Cape Town, Durban and Johannesburg. Committees in other regions will be established as and when required and will report back to

## VERSLAG OOR DIE DIE STANDAARD-REGULASIE VIR DIE BEDRAING VAN PERSELE

Die Komitee het op 4 Augustus 1966 oorweging geskenk aan etlike voorstelle wat van sy Wes-Kaaplandse en Natalse streeksonderkomitees, die Vereniging van Munisipale Elektriesiteitsondernemings, die Suid-Afrikaanse Buro vir Standaarde, die Departement van Arbeid, raadgewers en vervaardigers ontvang is en wat uit algemene briefwisseling voortgespruit het. Daar is besluit om die regulasies, wat in 1963 gewysig is, verder te wysig, en dié wysigings is gedruk en vertaal en teen Februarie 1967 uitgereik (die 1966-wysigings).

Die belangrikste wysigings geld die ligging en aarding van uitgangkontakte, vaste wasmasjiene, skottelgoedwasmasjiene, stowe, waterverwarmers en afvalwegruimingsenheede, en alternatiewe metodes vir die isolering van transformators en aardlekteestele is gespesifiseer. Danksy hierdie wysigings kan die bepaling van die regulasies nou streng op alle installasies (met inbegrip van haarkappersalonne, wasserye en laboratoriums) wat na 1 Januarie 1967 opgerig of verander is, toegepas word.

Die veertiende uitgawe van die Wiring Regulations of the London Institution of Electrical Engineers, wat onlangs verskyn het, was nog nie beskikbaar toe die Komitee in Augustus 1966 vergader het nie en kon dus nie bestudeer word nie.

Daar is tot aan die einde van 1966 reeds etlike duisende eksemplare van die Instituut se Bedraingsregulasies wat vir die eerste keer in September 1940 gepubliseer is, verkoop, en daar is 'n groot vraag na die gewysigde uitgawe van 1966. Drie gedrukte bladsye wysigings is beskikbaar ter aanvulling van die uitgawe van 1963.

R. LEISHMAN, Voorsitter.

## VERSLAG VAN DIE SUID-AFRIKANE KOMITEE INSAKE ELEKTROLITIESE KORROSIE

Daar is nie 'n verslag op die tegniese vergadering van een dag wat in 1966 in Bloemfontein gehou is, voorgelê nie, en hierdie verslag dek dus die twee jaar wat verloop het sedert die Konvensie wat in Mei 1965 in Port Elizabeth gehou is.

Die tiende en laaste vergadering van die Witwatersrandse Hoofkomitee insake Elektrolise is op 3 Junie 1965 in Johannesburg gehou. Die hoofbesprekingspunt was die konsepstatute waarkragens die Hoof- en Veldkomitees wat die Republiek se elektrolisevraagstukke bekamp, gereorganiseer en die veertienwoordigingsveld uitgebrei word. Die elektrifisering van die spoorweë in toenemende mate en die gewelddige uitbreiding in verband met water-, gas- en oliepleidings en die landsweye tramstelselne het dit genoodsaak.

Die eerste vergadering van die Suid-Afrikaanse Komitee insake Elektrolitiese Korrosie is op 24 Mei 1966 in Johannesburg gehou ten einde die konsepstatute formeel goed te keur en streeksveldkomitees vir Kaapstad, Durban en Johannesburg te benoem. Die komitees in ander streke sal gestig word na

the Main Committee which will issue Codes of Practice as necessary.

Regional Field Committees are currently busy preparing plans of the many underground services in their areas susceptible to electrolytic attack, doing field tests on direct current circulation and preparing plans for properly co-ordinated protective measures.

R. LEISHMAN,  
A.M.E.U. Representative on Main Committee

#### REPORT OF THE CO-ORDINATING COMMITTEE FOR HIGH-VOLTAGE FACILITIES

On 26th April 1966, a meeting of the full Committee was held representing the C.S.I.R., S.A.B.S., Escom, Universities, S.A.R. & H. and A.M.E.U. They reviewed the research programmes in hand relating to high voltage and the facilities available at various centres.

Subsequently a small sub-committee of the above body met to consider means of furthering the work of the main Committee. It was decided that three members be nominated to investigate work which should be undertaken under three headings:-

1. Professor Bozoli — H.V. testing of insulation and effects of voids, ionisation, etc.
2. Professor Heymann — Ionisation and corona.
3. Mr. Anderson — Lighting and long spark discharges.

It is proposed to hold a one-day symposium at Kelvin House, Johannesburg, during August at which a review will be given of work being done in the high-voltage field and contributions and suggestions regarding desirable subjects for research will be welcomed.

March, 1967.

gelang dit nodig is en hulle sal aan die Hoofkomitee verslag doen. Die Hoofkomitee sal dan die nodige gebruikskodes uitreik.

Die Streeksveldkomitees stel tans planne op van die tal van ondergrondse stelsels in hulle gebiede wat aan elektrolitiese korrosie onderhewig is. Hulle voer ook veldtoetse in verband met gelykstroomette uit en stel planne op waarvolgens behoorlik gekoördineerde beveiligingsmaatreëls getref kan word.

R. LEISHMAN,  
V.M.E.-Vertenwoordiger in die Hoofkomitee

#### VERSLAG VAN DIE KOÖRDNERENDE KOMITEE VIR HOOGSPANNINGS- FASILITEITE

'n Vergadering van die volle Komitee is op 26 April 1966 gehou, by welke geleentheid die W.N.N.R., die S.A.B.S., Evkom, die Universiteit, die S.A.S. en H. en die V.M.E.O. verteenwoordig was. Hulle het die navorsingsprogramme in oënskou geneem waaraan tans gewerk word en wat betrekking het op hoogspanning en die fasiliteite wat in die verskillende sentra beskikbaar is.

Later het 'n klein subkomitee van bogemelde liggaam byeengekóm om oorweging te skenk aan metodes waarvolgens die werksaamheid van die hoofkomitee bevorder kan word. Daar is besluit om drie lede te nomineer om ondersoek in te stel na die werk wat onder die volgende drie hoofde uitgevoer behoort te word:-

1. Professor Bozoli — Hoogspanningsisolasië-toetse en die uitwerking van ledige ruimtes, ionisasie, ens.
2. Professor Heymann — Ionisasie en korona.
3. Mnr. Anderson — Weertlig en langvonk-ontladings.

Daar word beoog om gedurende Augustus 'n eendaagse simposium by Kelvinhuis, Johannesburg, te hou, by welke geleentheid die werk wat in verband met hoogspanning gedoen word, onder die vergrootglas sal kom en waar bydraes en wenke omtrent geskikte onderwerpe vir verdere navorsing verwelkom sal word.

R. LEISHMAN,  
Maart 1967. Sameroeper.

## ADMINISTRATION AND DELEGATION PROBLEMS

Councillor H. G. Kipling, A.M.I.E.E., A.M.I. Mech. E.,  
M.S.A.I.L.S.O.

(Chairman, Work's Committee, East London City Council)

I have been asked to say a few words today about administration from the point of view of a municipal councillor. What action a councillor expects of an established administration. What gives rise to the necessity of changing the existing administration, and how such changes can be effected, because it becomes very clear to councillors from time to time, that changes are necessary to deal with a developing situation in the growth of a municipal service. As this discussion in the main centres around the Engineering aspect of the municipal set up, it is coincidental that I as an Engineer should be requested to set out a Councillor's view point in connection with the administration and delegation of problems as they exist at present.

Basically, I feel a councillor is always conscious of his responsibilities, and decisions are taken to effect an harmonious adjustment between these various sectional responsibilities for the benefit of all concerned, although the benefits received may not be as large as the recipients have requested. For the sake of convenience the background responsibilities are listed, not necessarily in order of importance or essentiality but rather as a framework for discussion.

1. Responsibility to the ratepayers.
2. Responsibility of the Council and committees as a whole in the light of previous commitments and precedents.
3. Responsibility to the staff.
4. Responsibility to the needs of the various municipal departments.
5. Responsibilities to the central and provincial governments.

The ramifications of the subject are very wide, and it is not proposed to deal with all of the points mentioned, but rather to pinpoint and concentrate on the responsibility for the needs of a municipal department, leaving other matters for discussion at some future date. However, it is clear that any discussion should be within the framework of the total responsibilities.

### ESTIMATES

One of the first points to arise is the question of estimates, and let's be frank about it, municipal departments do over estimate, the councillors know it, and the departments do themselves a disservice because councillors feel they are being taken for a ride. The result is arbitrary cuts which please no one, least of all the Council, but which have to be made to balance the budget.

## VRAAGSTUKKE VAN ADMINISTRASIE EN DELEGASIE

Raadslid H. G. Kipling, A.M.I.E.E., A.M.I. Mech. E.,  
M.S.A.I.L.S.O.

(Voorsitter, Werkekomitee, Stadsraad van Oos-Londen)

Ek is gevra om vandag 'n paar woorde te sê omtrent administrasie, gesien uit die oogpunt van 'n munisipale Raadslid — watter optrede 'n Raadslid van 'n gevestigde organisasie verwag, wat dit nodig maak om die bestaande administrasie te verander en hoe sulke veranderinge aangebring moet word. Dit word naamlik vir Raadslede van tyd tot tyd baie duidelik dat veranderinge nodig is om met ontwikkelende situasies in die groeiproses van die munisipale diens tred te hou.

Aangesien hierdie bespreking hoofsaaklik met die ingenieursaspekte van die munisipale diens te doen het, is dit heel toevallig dat ek, as 'n ingenieur, gevra is om die standpunte van 'n Raadslid teenoor die administrasie en delegasie van probleme, soos hulle vandag bestaan, uiteen te sit.

Eerstens voel ek dat 'n Raadslid altyd bewus is van sy verantwoordelikhede en dat besluitte geneem word met die oog op die harmonieuse ko-ordnering van hierdie uiteenlopende verantwoordelikhede ten voordele van alle betrokkenes, alhoewel die uiteindelige voordele miskien nie so groot mag wees as waarvoor die persone vir wie dit bestem is, oorspronklik gevra het nie. Gerieflikheidsshalwe word die grondliggende verantwoordelikhede aangedui, nie noodwendig in rangorde van belangrikheid of noodsaaklikheid nie, maar eerder as 'n raamwerk vir die bespreking.

1. Verantwoordelikheid teenoor die belastingbetalers.
2. Verantwoordelikheid van die Raad en sy komitees as geheel in die lig van voorafgaande verbindings en presedente.
3. Verantwoordelikheid teenoor die personeel.
4. Verantwoordelikheid teenoor die behoeftes van die verskillende munisipale departemente.
5. Verantwoordelikheid teenoor die Sentrale Regering en die Provinsiale owerhede.

Die vertakkinge van hierdie onderwerp is besonder wyd en daar word nie beoog om in hierdie verhandeling al die bogenoemde punte te behandel nie, dog eerder om die soeklig te laat val en te konsentreer op die verantwoordelikheid teenoor die behoeftes van 'n munisipale departement. Die ander sake kan oorgelaat word vir bespreking by 'n latere geleentheid. Dit is egter duidelik dat sodanige bespreking binne die raamwerk van die totale verantwoordelikhede van die Raadslid behoort plaas te vind.

### DIE BEGROTING

Een van die eerste sake wat hom aan ons voordoen, is die kwessie van die begroting. Laat ons nou maar eerlik wees: munisipale departemente is geneig om te ruim te begroot; die Raadslede is daarvan bewus en die departemente bewys hulself eintlik daardeur 'n onguns, omdat die Raadslede die gevoel kry dat hulle om die bos gelei word. Die gevolg is 'n reeks arbitrêre besnoeiings wat niemand tevrede stel nie (die Raad self allermins) maar wat tog nodig is om die begroting te laat kloep.

Various reasons are given for the situation, and generally it is found that the engineer achieves his goal, but this does not always ensure that he has the support of the councillors in the matter. This is detrimental for administration of the council's affairs, and is a matter that should receive earnest and careful consideration. Elimination of the practice will lead to harmonious co-operation between councillors and officials.

#### AUTONOMY OF THE ELECTRICITY DEPARTMENT

An interesting feature of the municipal scene which has been observed and commented on by councillors, is the strong growth of the engineering departments concerned with roads, water, sewerage and electricity and it is apparent that this growth will continue by the increasing demand of the services provided for the ratepayers and citizens by these departments. We thus have two departments growing at a faster rate than the others, bringing in its train problems of continuous adjustment pinpointed by the difficulties that arise due to the shortage of engineers and engineering artisans. If this cannot be adjusted within the existing established system, then in my opinion the problems will increase.

The expensive way to handle these problems, is to engage consultants and contractors, but you are still left with the matter of maintenance, for which a staff has to be provided in any case. Since this staff would be in contact with outside staff, there would be a continual drain of trained personnel, from the municipality to consulting engineers and contractors. The municipalities then find themselves in the position of training people who will leave for higher remuneration.

Accepting these arguments leads to the proposal that the engineer's departments should be separated from the normal municipal set up, and given an autonomy of their own to match the pace of their development. There is no suggestion for "empire building", or the creation of a managerial unit in isolation in the municipal set up, resulting in irregularities of application of municipal procedure.

What is envisaged is a managerial unit or units reporting vertically to the Council, wherein responsibility and authority are never separated. In this manner the most effective results can be obtained in meeting an ever changing development, and the departments concerned would operate with maximum control under a responsible engineer, who would be responsible to the Council for all functions of administration.

Every engineer is aware that effective work requires efficient men, and the necessary materials.

Verskillende redes word vir hierdie situasie opgegee, en die Ingenieur bereik gewoonlik sy doel, dog dit beteken nie noodwendig dat hy die steun van die Raadslede in verband met die aangeleentheid geniet nie. Dit het 'n nadelige uitwerking op die administrasie van die Raad se sake en dit is 'n aangeleentheid wat ernstige en deeglike oorweging behoort te geniet. Die uitkakeling van hierdie optrede kan slegs tot meer harmonieuse samewerking tussen Raadslede en amptenare aanleiding gee.

#### OTONOMIE VAN DIE ELEKTRISITEITSDEPARTEMENT

'n Interessante aspek van die munisipale toneel, wat reeds deur Raadslede raakgesien en bespreek is, is die ongekende ontwikkeling van die ingenieursdepartemente wat vir paaie, water, riolering en elektrisiteit verantwoordelik is en dit is duidelik dat hierdie groeitempo sal voortduur, as gevolg van die toenemende vraag na die dienste wat deur hierdie departemente aan die belastingbetalers en die ander inwoners van die dorp gelever moet word. Ons het dus twee departemente wat vinniger groei as die ander, welke feit voortdurende aanpassingsprobleme meebring. Hierdie probleme word vererger deur die moeilikhede wat ondervind word as gevolg van die tekort aan ingenieurs en toepaslik opgeleide amagslui. Indien hierdie probleme nie binne die raamwerk van die bestaande gevestigde stelsel opgelos kan word nie, is ek van mening dat die vraagstukke wat tans ondervind word, eerder sal vermeerder as verminder.

Die probleem kan die hoof gebied word deur konsultante en kontrakteurs in diens te neem, maar dit is 'n duur metode, en dit los nog nie die vraagstuk van instandhouding, waarvoor daar in ieder geval personeel aangehou moet word, op nie. Aangesien laasgenoemde personeel gedurig met personeellede van buite-firmas in aanraking kom, het dit tot natuurlike gevolg dat munisipale personeel voortdurend deur die konsultante en kontrakteurs aangelok word. Die munisipaliteit vind hulself dus in die posisie dat hulle personeel moet oplei, net om hulle dan weer te verloor as gevolg van die hoër besoldiging wat elders aangebied word.

Die aanvaarding van hierdie argumente bring ons by die voorstel dat die ingenieursdepartemente van die res van die normale munisipale opset geskei en met 'n eie otonomie bekleed moet word wat by die tempo van hul ontwikkeling sal aanpas. Dit beteken geensins die bou van keiserryke of die skepping van 'n geïsoleerde bestuurseenheid binne die munisipale diens nie, want dit sal slegs onreëlmatighede in die toepassing van munisipale prosedure-beginsels in die hand werk.

Wat wel in die vooruitsig gestel word, is 'n bestuurseenheid of -eenhede wat vertikaal aan die Raad verslag doen en waarin daar geen skeiding tussen verantwoordelikhede en gesag is nie. Op hierdie wyse kan die mees effektiewe resultate verkry word om 'n steeds veranderende ontwikkelings tempo die hoof te bied en die betrokke departemente kan hul taak volvoer met die grootste moontlike mate van beheer deur 'n verantwoordelike ingenieur, wat vir alle administratiewe funksies aan die Raad aanspreeklik is.

Elke ingenieur weet dat 'n bekwame personeel en die nodige materiaal voorvereistes vir doeltreffende werkverrigting is.

Under present conditions the basic requirement is men, and setting up an autonomous department would require a separate salary grading system for engineers and engineering artisans and technicians. The administrative power to instruct and control engineering staff which at present is a function of the Town Clerk and City Treasurer, would be transferred to the engineer who would take full disciplinary power in the department, with the Staff Committee acting as a court of appeal. In financial matters the engineer would be the responsible officer with the City Treasurer acting in a consultative capacity to the Finance committee. The materials position would remain as at present with the engineer responsible for selection and use, reporting to the Works Committee.

Streamlining the functions of the department vertically downwards from the Council and committees and transferring authority to a channel which could not shelve its responsibilities will in my opinion lead to greater efficiency, promote economy in time and paper work, reduce intrusion by other committees and so present full details to councillors who after all have to concentrate on the problem and make the decisions.

#### PRECEDENT, PRINCIPLE AND POLICY

Among the most frustrating problems with which a councillor has to contend, are these three items.

In municipal parlance, a **Precedent** is an act of administration, authorised by a previous council for reasons best known to themselves. With the passage of time it is impossible to determine the reasons for the voting. Usually no fully reasoned argument is available for consultation, and one is left with the impression rightly or wrongly, that subsequent Councils should not be bound by the precedent created. The value of a precedent lies in its binding effect administratively. It creates a status quo, which must be maintained, but to my mind its usefulness declines with changing circumstances, and its value in any case for decision should be reduced in the light of new developments. However, we still have resolutions carrying the proviso, that the terms thereof must not be regarded as precedents but the value of such a resolution is doubtful.

In regard to resolutions and decisions approved in **Principle**, this is an indefinite position, because if the principle is not implemented there is no binding decision. It therefore follows that the matter goes no further and the whole procedure is obviously a waste of time. If on the other hand the resolution in principle is eventually followed by a decision to take action, then the principle is accepted as council policy which can be taken as binding during the period of office of the Council. In such cases it would appear that a principle is

Onder heersende omstandighede is bekwame personeel die basiese vereiste, en om 'n outonome departement daar te stel, sal daar 'n aparte salarisgraderingstelsel vir ingenieurs en ingenieurs-ambagsmanne en tegnici nodig wees. Die administratiewe bevoegdheid om ingenieurspersoneel te beheer en opdragte aan hulle te gee, wat tans die funksie van die Stadsklerk en die Stadstoesourier is, sal dan oorgedra word aan die Ingenieur, wat dan volle dissiplinêre bevoegdheid in die departement sal oorneem, terwyl die Personeelkomitee die rol van 'n hof van appél sal vervul. Wat finansiële sake betref, sal die Ingenieur die verantwoordelike amptenaar wees, met die Stadstoesourier in die hoedanigheid van finansiële adviseur van die Finansieskomitee. Wat voorraad en materiaal betref, sal die posisie onveranderd bly, d.w.s. die Ingenieur sal verantwoordelik bly vir die seleksie en gebruik daarvan, terwyl hy aan die Werkekomitee verslag doen.

Die stroombelyning van die werksaamhede van die departement vertikaal afwaarts vanaf die Raad en die Komitees en die oordrag van bevoegdheid aan 'n kanaal wat nie sy verantwoordelikhede op die langebaan kan skuif nie, sal na my mening groter doeltreffendheid in die hand werk, besparing van tyd en kantoorwerk bevorder, inmenging deur ander komitees verminder en sodoenste meehelp om volle besonderhede aan die Raadslede te verskaf, wat per slot van sake die persone is wat op die probleme wat ter sake is, moet konsentreer en die beslissings moet vel.

#### PRESEDENTE, BEGINSELS EN BELEID

Hierdie drie sake vorm die mees frustrerende probleme waarmee die Raadslid te kampe het.

In munisipale taal is 'n **presedent** 'n administratiewe handeling wat deur 'n vorige Raad gemagtig is vir redes wat in baie gevalle slegs aan hulle bekend is. Na verloop van tyd is dit onmoontlik om te bepaal waarom daar toentertyd gestem is soos daar wel gestem is. Daar is gewoonlik geen ten volle gemotiveerde argument beskikbaar aan die hand waarvan die saak beoordeel kan word nie, en, ten regte of ten onregte, kry 'n mens die gevoel dat latere Rade nie deur die presedent wat geskep is, behoort gebind te word nie. Die waarde van 'n presedent lê in die bindende krag wat dit op administratiewe vlak het. Dit skep 'n status quo wat gehandhaaf moet word, maar die bruikbaarheid daarvan neem, na my mening, af wanneer omstandighede verander en by die neem van besluite behoort die waarde daarvan in die lig van nuwe ontwikkelinge in heroorweging geneem te word. Ons kry egter nog dikwels besluite wat onderhewig is aan die voorbehoud dat hulle nie as presedente beskou moet word nie. Die waarde van so 'n besluit is egter twyfelagtig.

Die posisie met betrekking tot besluite en aanbevelings wat in **beginsel** geneem of goedgekeur word, is vaag, want as die beginsel nie ten uitvoer gebring word nie, is daar geen bindende besluit nie. Dit volg vanself dat die saak nie verder gevoer kan word nie en dat die hele prosedure klaarblyklik op 'n verkwisting van tyd neerkom. Aan die ander hand, indien die beginselbesluit te eniger tyd gevolg word deur 'n besluit om handelend op te tree, dan word die beginsel aanvaar as die beleid van die Raad en kan dit beskou word dat dit die Raad gedurende sy hele amptstermyn bind. In sulke gevalle kom dit dus voor dat 'n beginselbesluit die helfte van



halfway to a policy, and is adopted to give councillors more time to reflect on a matter, and in this respect as previously, is a delay.

Questions of **Policy** are the main spring of municipal affairs which have often to be wound up to keep the municipal organisations on the right lines.

Avoiding the general aspects of the matter, my remarks in this respect are confined to the policies of electricity departments. Very often policy is decided by the ratepayers who elect councillors to give effect to what is local policy at the time of the elections. On other occasions, policy to meet changing circumstances has to be determined by the council in office, and this may be ratified by the ratepayers at a subsequent election. At all events policy making is the prime duty of a councillor individually and of the Council as a whole and the action of taking a policy decision can be regarded as a sound appreciation based on full and reliable information appertaining to any particular problem or difficulty. The municipal ramifications are wide. Councillors cannot in the time at their disposal give consideration to all aspects of a particular matter. To ensure a proper division of labour among the councillors, the committee system is instituted wherein policy is formulated for submission to the full council for final decision. This system to give effect to the wishes of the ratepayers is correct.

Summing up, my general feeling is when matters involving precedents and principles are brought up for discussion, the issues should be resolved, as is policy, on the merits of the case presented.

#### DELEGATION OF POWERS

In the larger municipalities, and maybe the smaller organisations as well, a tremendous amount of detail work is submitted to the council for decision and authorisation; on occasions urgent movement is held up pending the regular council meeting, and often a number of minor matters within the framework of previous policy decisions come up for ratification and confirmation. Councillors observing the scene have pondered on these matters and suggested delegation of powers to committees, to dispose of routine matters at present requiring Council authorisation. Some have gone further and proposed one committee to manage the affairs of the Council. Obviously under this committee system of delegated powers the individual councillor is deprived of his limited authority. He is prevented from voting on a committee even though he attends the meeting, and he is denied the opportunity of influencing proposals on policy at the formative stage and in-

die pad na 'n beleid is en dat dit geneem word om die lede meer tyd te gun om oor die saak na te dink. In hierdie opsig kom dit dus op 'n vertraging van die sak te staan.

Sake van **beleid** is die vernameste dryfveer van munisipale aangeleenthede, en dit is dikwels nodig om hierdie veer styf op te wen teneinde die munisipale organisasie op die regte spoor te hou.

Ek sal die algemene aspekte van hierdie saak links laat lê en myself by die beleidsake van elektrisiteitsdepartemente bepaal. Die beleid word dikwels neergelê deur die belastingbetalers, wat Raadslede verkies om uitvoering te gee aan wat ten tye van die verkiesing as plaaslike beleid beskou kan word. By ander geleenthede moet die Raad wat dan diens doen, die beleid bepaal om veranderende omstandighede die hoof te bied, en hierdie beleid kan dan by latere verkiesings deur die belastingbetalers goedgekeur word. In ieder geval is beleidsbepaling die mees verneme plig van die Raadslid as individu en van die Raad as 'n geheel, en die neem van 'n beleidsbesluit kan beskou word as 'n gesonde waardebeoordeling, gegrond op volledige en betroubare inligting aangaande enige besondere probleem of situasie. Die vertakkinge van die munisipale organisasie is baie wyd en daar kan nie van 'n Raadslid verwag word om, in die tyd tot sy beskikking, al die aspekte van 'n besondere aangeleentheid in oorweging te neem nie. Teneinde 'n doeltreffende arbeidsverdeling tussen die Raadslede te verseker, is die komiteestelsel ingestel, ingevolge waarvan daar voorlopige beleidsformulering plaasvind, wat daarna vir finale beslissing aan die Raad voorgelê word. Hierdie stelsel is na my mening die korrekte manier om aan die wense van die belastingbetalers uitvoering te gee.

By wyse van opsomming is ek oor die algemeen die mening toegedaan dat, wanneer sake waarby presidente en beginsels betrokke is, vir oorweging voorgelê word, die vraagstukke wat hulself voordoen, suiwer volgens meriete behandel behoort te word, net soos wat met beleidsake die geval is.

#### DELEGASIE VAN BEVOEGDHED E

By groter munisipaliteite, en heel waarskynlik by kleiner organisasies ook, word daar 'n geweldige hoeveelheid detail aan die Raad voorgelê vir beslissing en magtiging, by geleentheid word dringende werksaamhede vertraag omdat die Raad se beslissing afgewag word en dikwels word daar 'n groot aantal minder belangrike sake, wat almal binne die raamwerk van vorige beleidsbeslissings van die Raad val, vir goedkeuring of bekragtiging aan die Raad voorgelê. Raadslede wat hierdie toedrag van sake by herhaling waargeneem het, het daaroor begin nadink en het aan die hand gedoen dat sekere bevoegdhede aan komitees gedelegeer word, sodat hulle in staat sal wees om sake af te handel wat tans aan die Raad se magtiging onderworpe is. Sommige van hulle het veel verder gegaan en voorgestel dat slegs één komitee daargestel moet word om die Raad se sake te bestuur. Dit is duidelik dat die Raadslid se reeds beperkte magte onder hierdie stelsel van gedelegeerde bevoegdhede van 'n komitee nog verder ingekort sal word. Hy sal naamlik nie in 'n komitee stemreg hê nie, al woon hy ook die vergaderings van daardie komitee by, en die geleentheid om sy invloed uit te oefen op beleidsbeslissings in die vormingsstadium word hom ontse. Hy word dus veel meer 'n klages-agent as 'n doeltreffende Raadslid, en al wat daar vir

stead becomes an agent of complaint rather than an effective councillor, and he is left to endorse proposals on which he has to make reluctant and grudging concessions without regard to the true merit, in his opinion, of the issues involved.

Where the committee system is regarded as a division of work among the councillors, and the committees are considered as a specialised departmental organisation wherein the councillors and officials work together, the committee system has its greatest merit, as the atmosphere of the meeting tends to reduce the possibility of immature consideration, or hasty decision in respect of the department concerned and the Council as a whole, due to the fact that most councillors serve on more than one committee therefore council policy is well known and can be implemented.

This brings me to the point where delegation of the powers of the council to the committee could be considered. It is not suggested that a single committee consisting of three or five members should have delegated powers, leaving the balance of the councillors unrepresented on the working committee as this would tend to nullify the democratic principle of control by a body of elected representatives of the ratepayers and create the situation where a course of action repugnant to the balance of councillors could be taken and become irreversible and binding on the Council under the delegated powers.

What emerges from this and what is suggested is that delegated powers should be given to the various committees of the council to take action binding on the council where the committee sees fit and proper within the framework of policy. Such a course would speed up the municipal operations and lead to greater efficiency.

I might add that in the East London City Council certain matters of urgency have been ratified by the responsible committee by anticipating council sanction.

In conclusion, Mr. President, I must express my thanks to you and your executive for the courtesy extended to the Councillor representatives present, by including on the agenda of this convention an item of particular interest with which they are fully conversant, and therefore able to participate actively in the debate.

Previous conferences have always covered the electrical aspect of municipal undertakings, and while a few of us have been able to follow the papers and discussion, I am confident that a number of Councillors present have attended as an act of courtesy to their engineers. I trust that it will be possible at some future convention to include an item of particular interest to Councillors. This will eliminate the suggestion often expressed, that it is an unwarranted expense to allow councillors to attend these conventions.

hom oorby, is om sy goedkeuring te heg aan voorstelle ten aansien waarvan by teënsinniglik en wangunstiglik toegewings moet maak, sonder dat hy, na sy mening, die werklike meriete van die betrokke saak in oorweging kan neem.

Waar die komiteestelsel gesien word as 'n verdeling van werksaamhede tussen Raadslede en waar die komitees beskou word as 'n gespesialiseerde departementale organisasie waarin die Raadslede en die amptenare met mekaar saamwerk, daar het die komiteestelsel sy grootste waarde, omdat die atmosfeer van die vergadering in sulke gevalle die moontlikheid van onrype beraadslaging en oorhaastige beslissings ten opsigte van die betrokke departement en die Raad as 'n geheel, grootliks verminder. Die rede hiervoor is dat meeste Raadslede in meer as een komitee dien, met die gevolg dat die Raad se beleid goed bekend is en dus ten uitvoer gebring kan word.

Dit bring ons dan by die stadium waar die kwessie van die delegasie van die Raad se bevoegdhede aan die komitees in oënskyn geneem kan word. Daar word nie voorgestel dat 'n enkele komitee van drie of vyf lede met gedelegeerde bevoegdhede geklee moet word, terwyl die ander Raadslede sonder verteenwoordiging op die werkende komitee moet bly sit nie, aangesien dit die demokratiese beginsel van beheer deur 'n liggaam van verkose verteenwoordigers van die belastingbetalers ongedaan sal maak en 'n situasie kan skep waar daar 'n gedragslyn gevolg kan word wat die res van die Raadslede teen die bors stuit, dog wat, uit hoofde van die delegasie van bevoegdhede, onherroepbaar en vir die Raad bindend is.

Wat hieruit voortvloei en wat wel aan die hand gedoen word, is dat die verskillende komitees van die Raad met gedelegeerde bevoegdhede geklee moet word, sodat hulle, waar hulle dit binne die raamwerk van die Raad se beleid goed vind, stappe kan doen waardeur selfs die Raad gebonde sal wees. So 'n beleid sal die werksaamhede van die munisipaliteit bespoedig en groter doeltreffendheid in die hand werk.

Ek wil graag byvoeg dat, by die Stadsraad van Oos-Londen, sekere dringende sake reeds deur die verantwoordelike komitee afgehandel is, in afwagting van goedkeuring deur die Raad.

Ten slotte, Mnr. die President, wil ek u en u Bestuur graag van harte bedank vir die vriendelike gebaar teenoor die Raadslid-afgevaardigdes wat hier teenwoordig is, deurdat u in die sakelys van hierdie konvensie 'n item ingesluit het wat vir hulle van besondere belang is en waarmee hulle ten volle vertrou is, sodat hulle ook 'n aktiewe aandeel in die besprekinge kan neem.

By vorige kongresse het dit gewoonlik oor die elektrisiteits-aspekte van munisipale ondernemings gegaan, en, hoewel sommige van ons die referate en besprekinge wel kon volg, is ek daarvan oortuig dat baie Raadslede die kongresse slegs uit hoflikheid teenoor hul Ingenieurs bygewoon het. Ek vertrou dat dit ook by toekomstige kongresse moontlik sal wees om sake van besondere belang vir Raadslede in die sakelys in te sluit. Dit sal die mening wat soms gelug word, naamlik die bywoning van die kongresse deur Raadslede ongeregtigde uitgawes meebring, die nek inslaan.

# SOME ASPECTS OF STREETLIGHTING

by J. W. SMIT,  
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## 1. INTRODUCTION

An earlier paper<sup>1</sup> dealt in detail with the recommendations of the proposed SABS Code of Practice for Streetlighting. At the time the code was overseas for comment. It was in the interim period again reviewed by the technical committee and amended in accordance with suggestions received where appropriate.

The basic approach of the code however remains unchanged. It would therefore be sufficient to only recap the procedure of the code briefly, mention the major amendments and rather devote some space to a discussion of the methods used to present the photometric properties of a luminaire of which a clear understanding will greatly assist in the use of the code. In addition the results of tests on a recently completed installation are discussed and finally a section, which it is hoped will sufficiently stress the fact that good streetlighting is justified, is included.

## 2. PROCEDURE FOLLOWED IN THE CODE

The procedure adopted in the code may briefly be stated in the following steps:

- (1) The road is classified with the aid of a table as a freeway, trunk road, through road, etc.
- (2) The recommended values of road surface luminance, uniformity ratio, and type of luminaire, e.g. cut-off, semi cut-off, non cut-off, that should be used are found from the same table.
- (3) The minimum mounting height is found from a table of minimum recommended mounting heights.
- (4) The spacing required to produce the recommended values of luminance is then calculated from the luminous intensity distribution data of the luminaire and the luminous flux of the lamp.
- (5) Finally, a check is made to ensure that the uniformity ratio will conform to the recommendations of the code. Ideally the arrangement e.g. single sided, staggered, etc. should be chosen, as far as is practically possible, on the basis of best uniformity obtainable.

The foregoing procedure is repeated for each luminaire offered so that the final selection of the most suitable luminaire is made on a functional basis.

It is true that the method requires a greater effort on the part of the designer than the more widely used "recipe" me-

# ENKELE ASPEKTE VAN STRAATVERLICHTING

deur J. W. SMIT  
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## 1. INLEIDING

In 'n vroeëre verhandeling<sup>1</sup> het ek die aanbevelings van die voorgestelde Gebruikskode vir Straatverligting van die SABS in besonderhede behandel. Dié kode is destyds oorsê gestuur vir kommentaar. In die tussentyd is dit weer deur die tegniese komitee hersien en, waar nodig, gewysig in ooreenstemming met wenke wat ontvang is.

Die basiese benadering van die kode het egter onveranderd gebly. Dit is dus slegs nodig om kortliks die prosedure deur die kode beoog, uiteen te sit, die mees belangrike wysigings aan te stip en hiewers meer ruimte te wy aan 'n bespreking van die metodes wat gebruik word om die fotometriese eienskappe van 'n armatuur voor te stel, aangesien 'n dieptegrip hieromtrent groot hulp sal wees by die gebruik van die kode. Daarbenewens word die uitslae van die toetse wat op 'n onlangs-voltooidde installasie uitgevoer is, bespreek, en ten slotte is 'n hoofstuk bygevoeg waarin, na ek hoop, voldoende klem gelê word op die feit dat goeie straatverligting wel geregtig is.

## 2. PROSEDURE IN DIE KODE GEVOLG

Die prosedure wat deur die kode beoog word, kan kortliks soos volg opgesom word:-

- (1) Met behulp van 'n tabel word die betrokke pad as 'n snelweg, 'n hoofpad, 'n deurpad ens. geklassifiseer.
- (2) Met behulp van dieselfde tabel word die aanbevole waardes van die liggewendheid van die padoppervlakte, die eenvormigheidsverhouding en die tipe armatuur wat gebruik moet word (dws. afsny-, half-afsnij- of nie-afsnij) bepaal.
- (3) Die minimum-monteerhoogte word van 'n tabel van aanbevole monterhoogtes afgelees.
- (4) Die spasiering wat benodig word om die aanbevole ligwaardes te verkry, word dan met behulp van die lig-intensiteitsverspreidingsgegevens van die armatuur en die ligvloed van die lamp bepaal.
- (5) Laastens word gekontroleer of die eenvormigheidsverhouding aan die aanbevelings in die kode vervat, sal voldoen. By die keuse van die samestelling (dws. enkelsydig, verspringend ens.) behoort die oog sover moontlik op die grootste mate van uniformiteit wat beskikbaar is, gehou te word.

Dié prosedure word ten aansien van elke aangebode armatuur herhaal, met die gevolg dat die finale keuse van die mees geskikte armatuur op 'n funksionele grondslag geskied.

Dit is wáár dat hierdie metode groter inspanning vir die ontwerper meebring as die meer algemene "resep" — metodes

thods adopted by some other codes.

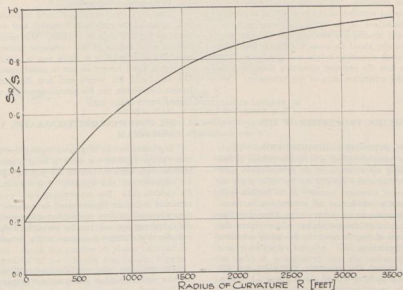
It offers ample refunds however. Firstly the method is dynamic — if widely used it must result in improvements of streetlighting equipment. Secondly it results in cost saving without sacrificing quality — an advantage which is well illustrated by the examples in the code. Finally it will lead to a better understanding of some of the problems in streetlighting by a wider range of people which will in turn assist development and progress.

### 3. MAJOR AMENDMENTS TO THE CODE SINCE CIRCULATION FOR COMMENT

A considerable number of small refinements were made to the code in view of comments received. It is not the purpose of this paper to detail them all.

Some of the more significant alterations are however listed below:

(a) **Spacing around a curve.** A graph (see Figure 1) showing the reduction of spacing around a curve has been included in the code. The recommendations do not differ materially from those given in the previous document but have merely been streamlined.



THIS GRAPH REPRESENTS THE FORMULA  $\frac{S}{R} = 1 - \frac{1}{10 \sqrt{\frac{R}{2840} + 0.1}}$

**FIGURE 1**

Graph for calculating the reduction in spacing around curves

Grafiek vir verminderde spasiering om draaie

wat deur sommige ander kodes voorgeskryf word, dog dit bied ruime voordele.

Eerstens is die metode dinamies van aard, en, indien dit algemeen gebruik word, moet dit noodwendig die verbetering van straatverligtingstoerusting tot gevolg hê. Tweedens bring dit kostebesparing mee sonder dat daar aan gehalte ingeboet word — hierdie voordeel word duidelik geïllustreer deur voorbeelde in die kode. Ten laaste sal dit lei tot 'n beter begrip van die probleme van straatverligting by baie meer mense, wat op sy beurt weer ontwikkeling en vooruitgang sal bevorder.

### 3. BELANGRIKSTE WYSIGINGE AAN DIE KODE SEDERT VRYSTELLING VIR KOMMENTAAR

'n Groot aantal kleinere verbeteringe is aan die kode aangebring in die lig van ontvangte kommentaar. Hulle word egter nie in hierdie verhandeling in detail behandel nie. Slegs enkele van die mees belangrike wysiginge word hieronder uiteengesit:-

(a) **Spasiering om 'n draai.** 'n Grafiek (Fig. 1) is in die kode ingesluit om die verminderde spasiering aan te toon. Die aanbevelinge verskil nie wesentlik van dié van die vorige dokument nie, dog is slegs enigins stroombelyn.

(b) **Table of recommended mounting heights.** In the original table the recommended mounting height was based on the total lumen output of the lamp. In the revised table (see Figure 2) the mounting height is dependent upon the peak intensity of the luminaire. Planning in accordance with the revised table should give a better consistency of glare limitation and road surface uniformity.

Fig. 2

**MINIMUM LUMINAIRE MOUNTING HEIGHTS**

Peak intensity candelas	Mounting height, min.*					
	Type of luminaire					
	Cut-Off ft. meter		Semi-cut-off ft. meter		Non-cut-off ft. meter	
Up to 1000	20	6.1	20	6.1	20	6.1
Over 1000 to 2000	25	7.6	25	7.6	25	7.6
Over 2000 to 4500	25	7.6	25	7.6	—	—
Over 4500 to 6000	30	9.2	30	9.2	—	—
Above 6000	30	9.2	35	10.7	—	—

\* These heights should be increased if the uniformity in a given installation is unacceptable.

(c) **Additional examples.** An additional example to illustrate how an existing installation can be modified to comply with the recommendations of the code, has been included. The arrangement and spacing are retained and the necessary improvement is brought about by using a different luminaire mounted at a different mounting height and overhang. The example illustrates how the required mounting height can be determined from the utilization data of the luminaire.

**4. THE PHOTOMETRIC PROPERTIES OF THE LUMINAIRE**

4.(1) **LUMINOUS INTENSITY DISTRIBUTION.** Luminous intensity in a given direction is formally defined as the luminous flux emitted by a source in an infinitesimal cone containing the given direction divided by the solid angle of that cone. The unit of luminous intensity is the candela (cd). The luminous intensity distribution of a luminaire is therefore the luminous intensity in a number of directions radiating from the optical centre of the luminaire — the higher the number of directions of known intensity the more complete the distribution information.

For practical reasons the luminous intensities are not given in haphazard directions around the luminaire, but at a number of regularly spaced angular intervals in altitude in a, number of regularly spaced vertical planes passing through the optical centre of the luminaire. The number of directions required in altitude in each vertical plane depends upon the rate of change of the intensity with angle. The result of a series of measurements in one such vertical plane can conveniently be expressed in polar graph form and is commonly referred to as a polar curve (see Figure 3).

**(b) Tabel van aanbevole monterehoogetes:**

In die oorspronklike tabel was die aanbevole monterehoogetes gebaseer op die totale lumenlewering van die lamp. In die hersiene tabel (Fig. 2) is die monterehoogete afhanklik van die spits-intensiteit van die armatuur. Bepanning wat aan die hand van die hersiene tabel gedoen word, behoort 'n meer konsekwente beperking van skittering ("glare") en meer eenvormigheid van pad-oppervlakte in die hand te werk.

Fig. 2

**MINIMUM-MONTEERHOOGETES VIR ARMATURE**

Spits-intensiteit Kandelas	Minimum-monterehoogete*					
	Soort armatuur					
	Afsny vt. meter		Half-afsnyn vt. meter		Nie-afsnyn vt. meter	
Tot 1000	20	6.1	20	6.1	20	6.1
Oor 1000 tot 2000	25	7.6	25	7.6	25	7.6
Oor 2000 tot 4500	25	7.6	25	7.6	—	—
Oor 4500 tot 6000	30	9.2	30	9.2	—	—
Bo 6000	30	9.2	35	10.7	—	—

\*Hierdie hoogtes moet vermeerder word as die eenvormigheid in 'n bepaalde installasie onaanneemlik is.

**(c) Bykomstige voorbeelde:-**

Daar is 'n bykomstige voorbeeld ingesluit om te illustreer hoe 'n bestaande installasie verander kan word om aan die vereistes van die kode te voldoen. Die rangskikking en spasiering word behou en die verlangde verbetering word wesenlik deur gebruik te maak van 'n ander soort armatuur wat op 'n ander hoogte en met 'n ander oorstek gemonteer is. Die voorbeeld dui voorts aan hoe die verlangde monterehoogete met behulp van die gebruiksgewens van die armatuur bepaal kan word.

**4. DIE FOTOMETRIESE EIENSKAPPE VAN DIE ARMATUUR**

Lig-intensiteit in 'n gegewe rigting word formeel gedefinieer as die ligvloed wat deur 'n bron uitgestraal word in 'n infinitesimale keël, bevattende die gegewe rigting, gedeel deur die liggaamshoek van die keël. Die lig-intensiteitseenheid is die kandela (kd). Die verspreiding van lig-intensiteit deur 'n armatuur is dus die lig-intensiteit in 'n aantal rigtings wat van die optiese middelpunt van die armatuur uitstraal — hoe hoër die aantal rigtings waarvan die intensiteit bekend is, hoe meer volledig is die inligting aangaande die verspreiding.

Om praktiese redes word die lig-intensiteit nie in 'n klomp lukrake rigtings rondom die armatuur aangegee nie, maar wel op 'n aantal reëlmatig-gespaasde hoekige tussenruimtes in hoogte in 'n aantal reëlmatig-gespaasde vertikale vlakke wat deur die optiese middelpunt van die armatuur loop. Die aantal rigtings in hoogte wat in elke vertikale vlak benodig word, hang af van die verandering van intensiteit teen verskillende hoek. Die uitslag van 'n reeks afmetinge in een vertikale vlak kan gerieflikheidshalwe in die vorm van 'n polare grafiek uitgedruk word en word gewoonlik 'n polare kurwe genoem. (Sien Fig. 3).

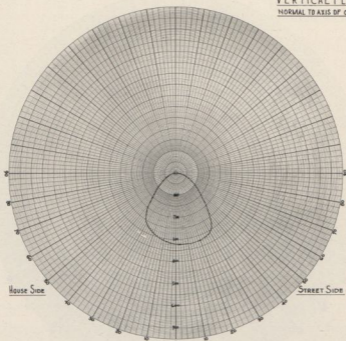


FIGURE 3  
POLAR CURVE OF A TYPICAL STREETLIGHTING LUMINAIRE IN  
VERTICAL PLANE AT AN ANGLE OF AZIMUTH OF  $0^\circ$   
Polare kurve van 'n tipiese Straatlig-armatuur in 'n vertikale  
vlak teen 'n asimutshoek van  $0^\circ$

If the luminaire has an axis of symmetry in respect of its intensity distribution, the information in one vertical plane as that shown in Figure 3 is sufficient as a rotation around the axis of symmetry gives the complete distribution picture.

Streetlighting luminaires very seldom have an axis of symmetry but are normally designed to have a plane of symmetry (the plane parallel to the axis of the carriageway). In this case a number of polar curves at regular intervals in azimuth is required. Again the number of planes required is dictated by the regularity of the intensity distribution. Figures 3, 4, and 5 shows three polar curves at angles of azimuth of  $0^\circ$ ,  $70^\circ$  and  $90^\circ$  for a typical streetlighting luminaire.

It is usually found that measurements at angles of altitude at 10 degree intervals and in planes spaced at angles of azimuth of 10 degrees give sufficient information for streetlighting luminaires.

Figures 6 and 7 show the distribution photometer which is now in use at the Bureau for the measurement of luminous intensity distribution of streetlighting luminaires.

Indien die armatuur 'n simmetriese as ten aasien van sy intensiteitsverspreiding het, is die inligting wat in een vertikale vlak verkry is, soos in Fig. 3 aangedui, voldoende, aangesien 'n rotasie rondom die simmetriese as vir ons die volledige verspreidingsprentjie skilder.

Straatlig-armature het heel selde in simmetriese as, dog word gewoonlik ontwerp om 'n simmetriese vlak te hê (die vlak wat ewewydig met die oppervlakte van die rybaan loop.) In hierdie gevalle word 'n aantal polare kurwes teen gereelde asimutstussenposes benodig. Ook hier word die aantal vlakke wat nodig is, voorgeskryf deur die reëlmatigheid van die intensiteitsverspreiding. Figure 3, 4 en 5 toon drie polare kurwes teen asimutshoeke van  $0^\circ$ ,  $70^\circ$  en  $90^\circ$  ten opsigte van 'n tipiese straatlig-armatuur.

Daar is gevind dat metings teen hoogtehoeke met tussenposes van 10 grade en in vlakke teen asimutshoeke van 10 grade gepasieer, genoegsame inligting ten opsigte van straatlig-armature verstrek.

Figure 6 en 7 toon die verspreidingsligmeter wat tans deur die Buro gebruik word om die lig-intensiteitsverspreiding van straatligarmature te meet.

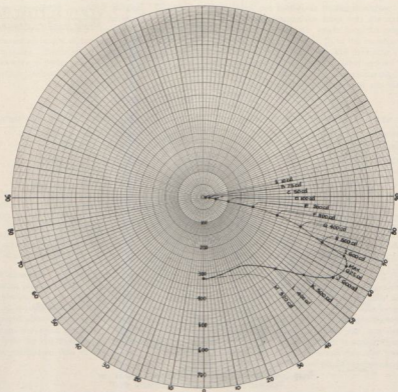


FIGURE 4.  
 POLAR CURVE IN A VERTICAL PLANE AT AN ANGLE OF AZIMUTH OF  $70^{\circ}$   
 (AZIMUTH IN THE DIRECTION OF MAXIMUM INTENSITY)  
 Polare kurve in 'n vertikale vlak teen 'n asimutshoek van  $70^{\circ}$   
 (Asimut in die rigting van die maksimum intensiteit)

4.(2) **THE ISO-CANDELA DIAGRAM.** The fact that the luminous intensity distribution of a luminaire in the form of polar curves gives all the photometric information which is required for design purposes is often overlooked. By applying the inverse square law the illumination at any point on the road surface can be calculated from the luminous intensity in the direction of the point. A knowledge of the illumination level at a sufficient number of such points again leads to the average illumination and a value for the illumination uniformity ratio.

It is however quite cumbersome to work from polar curves and true to human nature, ways have been found to present the information in a more concise and useful manner. Unfortunately, as is often the case, this desire of some individuals to find a simpler method leads only to the confusion of many others. This is certainly the case with the iso-candela diagram which always causes a frown and even gave rise to a

4.(2) **DIE ISO-KANDELA-DIAGRAM**

Die feit dat die lig-intensiteitsverspreiding van 'n armatuur, in die vorm van polare kurwes aangegee, al die fotometriese inligting verskaf wat vir ontwerpdoeleindes nodig is, word dikwels oor die hoof gesien. Deur die wet van omgekeerde kwadrate toe te pas, kan die illuminasie by enige punt op die pad-oppervlakte bereken word vanaf die lig-intensiteit in die rigting van daardie punt. Indien die illuminasiepeil by 'n voldoende aantal sodanige punte bekend is, kan die gemiddelde illuminasie bereken en die waarde van die eenvormigheidsverhouding van die illuminasie bepaal word.

Om vanaf polare kurwes te werk, is egter moeilik, en getrou aan die menslike natuur, het mense metodes probeer vind om die inligting in 'n meer beknopte en bruikbare vorm aan te bied. Ongelukkig, soos wat dikwels gebeur, dien hierdie behoefte van individue om eenvoudiger metodes te vind, slegs die doel dat dit vir andere tot verwarring lei. Dit is beslis die geval met die iso-kandela-diagram, wat gewoonlik

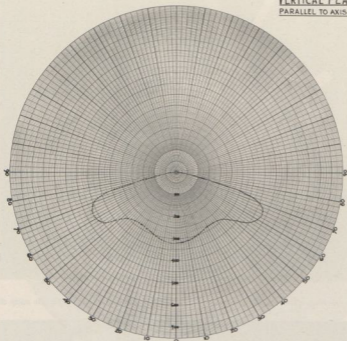


FIGURE 5  
 POLAR CURVE IN A VERTICAL PLANE AT AN ANGLE OF AZIMUTH OF 90°  
 Polare kurve in 'n vertikale vlak teen 'n asimuthhoek van 90°

title of an excellent paper to be chosen as "Iso-Candelas Simplified or Onions Without Tears".

In order to understand the iso-candela diagram properly let us imagine that the luminaire, in its normal operating position, is placed in the centre of a large sphere. If the luminous intensity at different points of equal intensity on the surface of the sphere are joined by a smooth curve on the surface of the sphere, an iso-candela line is obtained. If in addition now the surface of the sphere is divided into lines of longitude and latitude (to use map-making terminology) then each of the lines of longitude represents a direction in azimuth and each line of latitude represents a direction in elevation as seen from the luminaire (see Figure 8).

Clearly then, if a number of ISO-candela lines representing different luminous intensities are drawn on the surface of our imaginary sphere we have a second method of presenting the distribution data of the luminaire with the added advantage that the number of graphs required to reflect this information has been considerably reduced. In actual fact the number of graphs have been reduced to only two — one hemisphere representing 180° in azimuth on one side of the luminaire. If the luminaire has a plane of symmetry, which is the

tot suur gesigte aanleiding gee en wat selfs as inspirasie gedien het vir die titel van 'n uitstekende verhandeling, nl. "Iso-Candelas Simplified or Onions Without Tears".

Teneinde die iso-kandela-diagram behoorlik te begryp, moet ons onself voorstel dat die armatuur, in sy normale werkende posisie, in die middel van 'n groot sfeer geplaas is. Indien die ligintensiteit by verskillende punte van gelyke intensiteit op die oppervlakte van die sfeer nou by wyse van 'n gladde kromme op die oppervlakte van die sfeer met mekaar verbind word, word 'n iso-kandela-lyn verkry. Indien die oppervlakte van die sfeer nou nog boonop in lengte- en breedtegrade verdeel word (om van aardrykskundige terme gebruik te maak), dan verteenwoordig elke lengtegraadlyn 'n asimutrigting en elke breedtegraadlyn 'n hoogtegrigting, soos vanaf die armatuur gesien. (Sien figuur 8.)

Dit is dus duidelik dat, indien 'n aantal iso-kandela-lyne om verskillende lig-intensiteite aan te dui, op die oppervlakte van ons denkbeeldige sfeer getrek word, ons 'n tweede metode gevind het om die verspreidingsgegevens van die armatuur aan te dui, met die bykomstige voordeel dat die aantal grafieke wat nodig is om hierdie inligting weer te gee, aansienlik verminder is. Die getal grafieke het in werklikheid tot twee verminder — een halfrond wat 180 asimutgrade aan die een kant van die armatuur verteenwoordig. Indien die armatuur



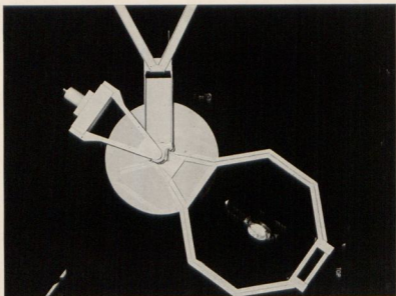


Fig. 6

View of Photometer from a position close to the photocell

Die Fotometer vanuit 'n posisie naby die fotosel gesien

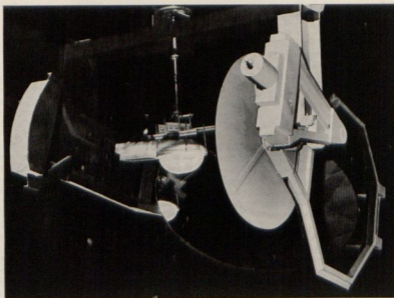


Fig. 7

View of Photometer from the side

Sy-aansig van die fotometer

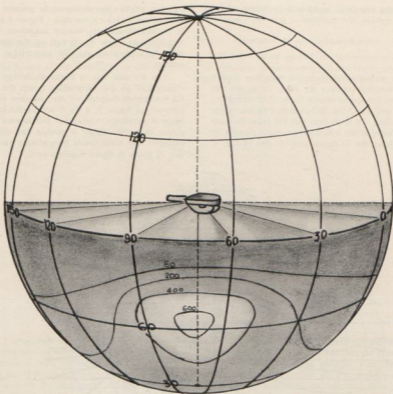


FIGURE 8

SPHERICAL SURFACE WITH ISO-CANDELA LINES.

Sfeer-oppervlakte met iso-kandela-lyne

case for almost all streetlighting luminaires, only one hemisphere is sufficient.

A big disadvantage of plotting the ISO-candela lines on the projected surface of a sphere becomes apparent at a moment's consideration of Fig. 8. Since the lines are crowded together near the edges of the diagram, accuracy deteriorates very rapidly in these regions. This problem can of course be solved if the surface of the sphere is flattened out. This can be done by subdivision but there must then be distortion, either of shape or area or both. Mapmakers have solved this problem long ago and have developed a projection whereby there is distortion in **shape** only. This projection, which is sometimes referred to as the sinusoidal equal-area projection, suits our purpose admirably. Fig. 9 is an example of an ISO-candela diagram showing the ISO-candela lines of Fig.

'n simmetriese vlak het, wat by feitlik alle straatlig-armature die geval is, dan is slegs een halfrond voldoende.

Die groot nadeel daarvan om die iso-kandela-lyne op die geprojekteerde oppervlakte van 'n sfeer aan te teken, word duidelik sodra ons figuur 8 ensins van naderby beskou. Aangesien die lyne naby die kante van die diagram teen mekaar vasgedruk is, ontstaan daar 'n vinnige afname in akkuraatheid in hierdie streke. Hierdie probleem kan natuurlik oorkom word deur die oppervlakte van die sfeer tot 'n gelykte af te plat. Dit kan deur middel van onderverdeling gedoen word, maar dan ontstaan daar vervorming, óf van vorm óf van grootte, of van albei. Landkaarttekenaars het hierdie moeilikheid lankal te bowe gekom en het 'n projeksie-metode ontwikkel waarin daar net vervorming van **vorm** plaasvind. Hierdie projeksie-metode, wat soms die sinus-

8 now plotted on the sinusoidal equal-area projection of the surface of the hemisphere.

To clarify the matter some more we may now briefly look into the relationship between the polar curve and the ISO-candela diagram for the luminaire from which the polar curves in Fig. 3, 4, and 5 and the ISO-candela diagram shown in Fig. 9 were obtained. It is obvious that the polar diagram in Fig. 4 can be plotted if the intensities at various angles in elevation are read from the 70 degree azimuth line in Fig. 9.

vormige gelyke-oppervlaktemetode genoem word, is by uitnemendheid geskik vir ons doel. Figuur 9 is 'n voorbeeld van 'n iso-kandela-diagram waarop aangetoon word die iso-kandela-lyne van figuur 8 wat nou op die sinusvormige gelyke-oppervlakte-projeksie van die oppervlakte van die halfrond geteken is.

Om die saak nog 'n bietjie duideliker te maak, kan ons vlugtig kyk na die verhouding tussen die polare kurwe en die iso-kandela-diagram vir die armatuur vanwaar die polare kurwes van figure 3, 4 en 5 en die iso-kandela-diagram in figuur 9 aangetoon, verkry is. Dit lê voor die hand dat die polare kurwe van figuur 4 geteken kan word indien die intensiteite teen verskillende hoogthoeke vanaf die asimutlyn van 70 grade in figuur 9 gelees word.

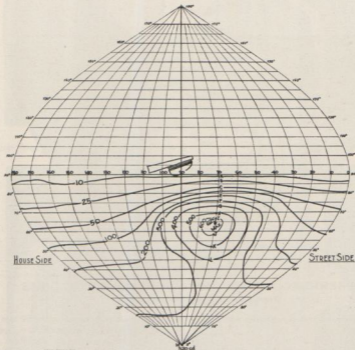


FIGURE 9  
ISO-CANDELA DIAGRAM FOR THE LUMINAIRE FROM WHICH THE POLAR CURVES IN FIGURES 3, 4 AND 5 WERE OBTAINED.  
Iso-kandela-diagram vir die armatuur vanwaar die polare kurwes in figure 3, 4 en 5 aangetoon, verkry is

#### 4.(3) THE USE OF THE ISO-CANDELA DIAGRAM.

Having discussed now what the ISO-candela diagram means, it remains to be seen what use can be made of it in street-lighting calculations. The method outlined in this section is that recommended by the Illuminating Engineering Society<sup>3</sup>. There are other methods of employing the ISO-candela diagram to arrive at the same ultimate result but space will not permit their discussion in this paper.

#### 4.(3) DIE GEbruik VAN DIE ISO-KANDELADIAGRAM

Noudat ons aangedui het wat die iso-kandela-diagram eintlik beteken, kan ons probeer bepaal welke gebruik daarvan gemaak kan word by berekeninge in verband met straatverligting. Die metodes wat in hierdie afdeling uiteengesit word, word deur die "Illuminating Engineering Society" aanbeveel.<sup>3</sup> Daar is ook ander metodes om die iso-kandela-diagram te gebruik om dieselfde uiteindelige resultaat te be-

4.3(1) **Development of Utilization Curves.** The road is divided into rectangular areas whose dimensions are expressed in terms of the mounting height of the luminaire, as shown in Fig. 10.

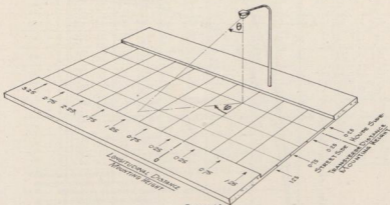


FIGURE 10  
STREET AREAS FOR LUMEN CALCULATION  
Straatgedeeltes vir lumenberekening

The luminaire is orientated so that the 90/270 degree plane forms the dividing line between the street side and the house side. The lumens in each rectangular area are computed by multiplying the luminous intensity in the direction of the centre of each area by the solid angle subtended at the luminaire by the area (this is known as the area constant of the zone in question). Why this is so is immediately evident if we think of the definition of luminous intensity. Summation of the lumens thus obtained in each area, in strips along the length of the road and finally of all the strips over the width of the road gives the total utilization over the particular road (the effective lumens on the carriageway expressed as a percentage of the bare lamp lumens). The utilization factor which is used in the proposed SABS code is just a convenient form of presenting utilization information so that it can be applied to calculate the average illumination of the carriageway surface for different geometries of installation (see fig. 11). It consists of a graph in which the summation of lumens in the first, the first +second etc. horizontal strips, expressed as a fraction of the total lamp lumens is set out on the y-axis and the ratio:

$$\frac{\text{width of street on the x-axis.}}{\text{mounting height}}$$

The summation of lumens in horizontal strips or areas along the length of the road can be very easily performed by using the table in Fig. 12.

reik, dog hierdie verhandeling bied nie genoegsame ruimte om daardie metodes te bespreek nie.

4.3(1). **Ontwikkeling van Gebruikskurwes**

Die pad word verdeel in reghoekige gedeeltes, waarvan die afmetinge ooreenkomstig die monterhoogtes van die armatuur, soos in figuur 10 aangetoon, uitgedruk word.

Die armatuur word s6 geplaas dat die 90/270-grade-vlak die skeidslyn tussen die straatkant en die huiskant vorm. Die lumens in elke reghoekige gedeelte word bereken deur die lig-intensiteit in die rigting van die middelpunt van elke gedeelte te vermenigvuldig met die liggaamshoek wat by die armatuur deur die reghoekige gedeelte onderspan word (dit staan bekend as die gebiedskonstante van die betrokke sone). Hoekom dit so is, is dadelik duidelik wanneer ons aan die definisie van lig-intensiteit dink. Die som van die lumens aldus in elke gedeelte verkry, in stoke al langs die lengte van die pad af, en ten slotte van al die stoke oor die breedte van die pad, gee vir ons die totale benutting oor die besondere pad (die effektiewe lumens op die ryvlak, uitgedruk as 'n persentasie van die lumens van die kaal lamp.) Die benuttingsfaktor wat in die voorgestelde kode van die S.A.B.S. gebruik word, is slegs 'n maklike manier om benuttingsinligting aan te bied, sodat dit gebruik kan word om die gemiddelde verligting van die oppervlakte van die ryvlak te bereken ten opsigte van verskillende installasieplasinge (sien figuur 11). Dit bestaan uit 'n grafiek waarin op die y-as die som van die lumens in die eerste, die eerste plus die tweede horisontale stoke, ensovoorts, aangedui word, uitgedruk as 'n breuk van die totale lumens van die lamp, en op die x-as die verhouding: wyde van straat monterhoogte.

Die som van die lumens in horisontale stoke of gebiede langs die lengte van die pad af kan baie maklik verkry word deur gebruik te maak van die tabel in figuur 12.

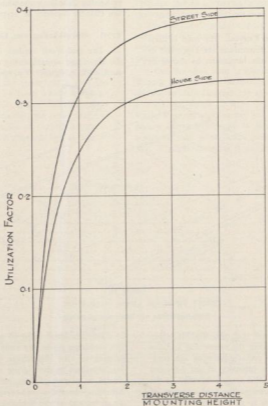


FIGURE 11  
TYPICAL EXAMPLE OF UTILIZATION CURVE

**Tipesie voorbeeld van 'n benuttingskurwe**

In this table K is the area constant. B and X are the angles of azimuth and altitude respectively which represent the direction of the centre of each rectangular area. The product of the factor K and the luminous intensity in the direction of B and X gives the total lumens incident on an area and the horizontal summation of the lumens in each area of one row of areas gives the total lumens in a horizontal strip on one side of the luminaire. The utilization in the strips on both sides of the luminaire is of course twice this value if the luminaire has a plane of symmetry.

The luminous intensity in the directions of B and X required by the table in figure 12 can be found from an isocandela diagram by interpolation. If transparencies such as those shown in Figure 13 are prepared to lay over the isocandela diagram the work is greatly simplified. Alternatively,

In hierdie tabel is K die gebiedskonstante, B en X is die asimuts- en hoogtehoeke onderskeidelik, wat die rigting van die middelpunt van elke reghoekige strook verteenwoordig. Die produk van die faktor K en die lig-intensiteit in die rigting van B en X gee die totale lumens wat op 'n gebied inval en die horisontale sommasie van die lumens in elke gebied in 'n ry gebiede gee vir ons die totale lumens in 'n horisontale strook aan die een kant van die armatuur. Die benutting in die stroke aan weerskante van die armatuur is natuurlik tweemaal hierdie waarde as die armatuur 'n simmetriese vlak het.

Die lig-intensiteit in die rigting van B en X, wat vir die gebruik van die tabel in figuur 12 nodig is, kan by wyse van interpolasie vanaf 'n iso-kandela-diagram verkry word. Indien deursigbeelde soos in figuur 13 aangedui, gemaak word om oor die iso-kandela-diagram te plaas, word die werk baie vereenvoudig. Alternatiewelik is gevind dat fotokopies van hierdie

Tabel vir berekening van benutting

FIGURE 13  
TABLE FOR THE CALCULATION OF UTILIZATION

Distances* Centre Street or Foot House	Utilization	Distances Along Street* (meters)															
		0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75	7.25	
0.25	K	0.2611	0.1585	0.1093	0.0782	0.0563	0.0406	0.0286	0.0197	0.0136	0.0093	0.0065	0.0045	0.0032	0.0023	0.0016	0.0011
0.25	X	16.9	11.6	8.2	5.9	4.3	3.2	2.3	1.6	1.1	0.8	0.5	0.4	0.3	0.2	0.1	0.1
0.33	K	0.1985	0.1284	0.0874	0.0626	0.0447	0.0323	0.0228	0.0157	0.0108	0.0072	0.0051	0.0037	0.0027	0.0019	0.0014	0.0010
0.33	X	13.4	9.0	6.4	4.6	3.4	2.5	1.8	1.3	0.9	0.7	0.5	0.4	0.3	0.2	0.1	0.1
1.25	K	0.0993	0.0649	0.0454	0.0324	0.0226	0.0157	0.0108	0.0072	0.0051	0.0037	0.0027	0.0019	0.0014	0.0010	0.0007	0.0005
1.25	X	6.3	4.2	3.0	2.2	1.6	1.1	0.8	0.5	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0
1.75	K	0.0692	0.0468	0.0331	0.0233	0.0166	0.0115	0.0076	0.0054	0.0039	0.0028	0.0020	0.0014	0.0010	0.0007	0.0005	0.0003
1.75	X	4.5	3.0	2.2	1.6	1.2	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
2.25	K	0.0507	0.0340	0.0245	0.0174	0.0122	0.0083	0.0058	0.0041	0.0029	0.0020	0.0014	0.0010	0.0007	0.0005	0.0003	0.0002
2.25	X	3.2	2.1	1.6	1.1	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
2.75	K	0.0368	0.0251	0.0177	0.0127	0.0087	0.0061	0.0043	0.0030	0.0020	0.0014	0.0010	0.0007	0.0005	0.0003	0.0002	0.0001
2.75	X	2.2	1.5	1.1	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
3.25	K	0.0271	0.0187	0.0135	0.0096	0.0067	0.0047	0.0033	0.0022	0.0015	0.0010	0.0007	0.0005	0.0003	0.0002	0.0001	0.0000
3.25	X	1.6	1.0	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.75	K	0.0198	0.0139	0.0100	0.0071	0.0050	0.0035	0.0024	0.0016	0.0011	0.0007	0.0005	0.0003	0.0002	0.0001	0.0000	0.0000
3.75	X	1.1	0.7	0.6	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.25	K	0.0147	0.0103	0.0074	0.0053	0.0037	0.0026	0.0018	0.0012	0.0008	0.0005	0.0003	0.0002	0.0001	0.0000	0.0000	0.0000
4.25	X	0.8	0.5	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.75	K	0.0109	0.0077	0.0056	0.0040	0.0028	0.0019	0.0013	0.0008	0.0005	0.0003	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
4.75	X	0.6	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.25	K	0.0081	0.0058	0.0042	0.0030	0.0020	0.0014	0.0009	0.0006	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
5.25	X	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

\* Distances are expressed in terms of mounting height and are measured from point below light centre.  
 \*\* B = Azimuth or horizontal angle from direction crosswise to street.  
 X = Vertical angle from nadir.  
 K = Lumen Factor.

we have found that slides of these diagrams can be projected over the iso-candela diagram, which is very useful, as the iso-candela diagrams are of varying sizes.

4.(3)2 The Iso-Illumination Diagram. Once the total lumens incident on each of the carriageway areas or rectangular intervals listed in Figure 12 has been calculated, the average horizontal illumination in each area can be found by dividing the incident lumens by the true area of the rectangular interval. Each rectangular area in Figure 12 has a length and a width of 0.5 times the mounting height up to ratios of 5 times the mounting height along the street and each rectangle in this region therefore has an area of  $(0.5 \times H)^2 = (0.25 \times H^2)$ . For ratios of 6 to 10, the length of each area is equal to the mounting height. Each rectangle in this region therefore has an area of  $(1 \times H)(0.5 \times H) = (0.5 \times H^2)$ . For example, if the mounting height is 20 feet the areas in the two regions are 100 and 200 square feet respectively.

It is now a simple step to the iso-illumination diagram for any chosen mounting height by plotting the illumination values at positions corresponding to the centres of rectangular intervals and joining points of equal illumination as shown in Fig. 14.

The table of correction factors that usually accompany an iso-illumination diagram gives the factor by which the value of illumination on each iso-illumination line must be multiplied if a mounting height other than that for which the illumination values calculated, is employed. Clearly this factor

diagramme oor die iso-candela-diagram projekteer kan word, wat natuurlik baie handig te pas kom, veral aangesien die iso-candela-diagramme nie altyd ewe groot is nie.

4.(3)2 Die Iso-Illuminatie-Diagram

Sodra die totale lumens wat op elkeen van die rybaan-gebiede of reghoekige gedeeltes in figuur 12 aangegeef, inval, bereken is, kan die gemiddelde horisontale illuminasie in elke gebied gevind word deur die invallende lumens deur die weroppervlakte van die reghoekige gebied te verdeel. Elke reghoekige gebied in figuur 12 het 'n lengte en 'n wydte van 0.5 keer die monterhoogte, tot by verhoudinge van 5 keer die monterhoogte langs die straat af, en elke vierkant in hierdie omstreke het dus 'n oppervlakte van  $(0.5 \times H)^2 = (0.25 \times H^2)$ . Vir verhoudinge van 6 tot 10 is die lengte van elke gebied gelyk aan die monterhoogte. Elke vierkant in hierdie gebied het dus 'n oppervlakte van  $(1 \times H)(0.5 \times H) = (0.5 \times H^2)$ . Byvoorbeeld, indien die monterhoogte 20 voet is, is die oppervlakte in die twee gebiede 100 en 200 vierkante voet onderskeidelik.

Dis is nou betreklik eenvoudig om die iso-illuminasie-diagram ten opsigte van enige gegewe monterhoogte te teken deur die illuminasie-waardes by plekke wat met die middelpunte van die reghoekige stroke ooreenstem, aan te stip en die punte van gelyke illuminasie met mekaar te verbind, soos in figuur 14 aangedui.

Die tabel korreksiefaktore wat gewoonlik 'n iso-illuminasie-diagram vergeet too aan die faktor waarmee die illuminasiewaarde van elke iso-illuminasielyn vermenigvuldig moet word indien gebruik gemaak word van 'n monterhoogte wat verskil van die hoogte ten opsigte waarvan die illuminasiewaardes bereken is. Hierdie faktor is klaarblyklik die ver-

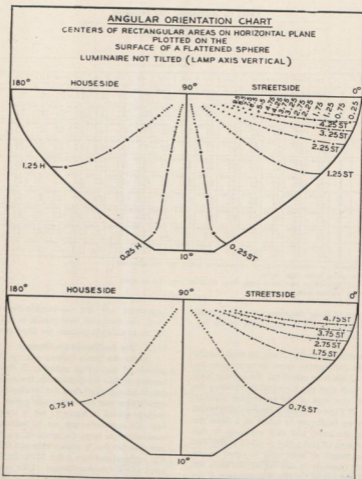


Fig. 13

Transparency to lay over isocandle chart to determine the values of candle power directed toward centres of rectangular areas. Two diagrams are used one for each alternate lengthwise strip of rectangular areas

Deursigbeeld om oor iso-kandela-diagram te plaas om die waarde van die kerskrag wat na die middelpunt van die reghoekige gebiede gerig is, te bepaal. Twee diagramme word gebruik — een vir elke alternatiewe langwerpige groep van reghoekige gebiede

is the ratio  $\frac{(Hc)^2}{(H)^2}$ , where Hc is the mounting height used in the calculation of illumination values and H is the mounting height to be used.

houding  $\frac{(Hc)^2}{(H)^2}$ , waar Hc die monterhoogte verteenwoordig wat by die berekening van illuminasiewaardes gebruik is, en H die monterhoogte wat gebruik gaan word.

**5. RESULTS OF TESTS ON A RECENTLY COMPLETED INSTALLATION**

Figure 15 shows the installation on the Sivewright-Berea

**5. UITSLAE VAN TOETSE OP 'N ONLANGS-VOLTOOIDE INSTALLASIE UITGEVOER.**

Figuur 15 toon die instalasie op die Sivewright-Berea

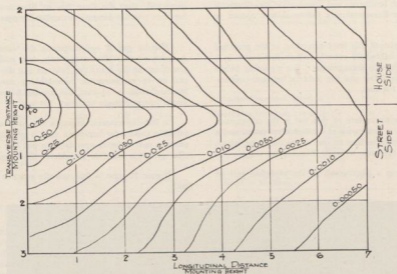


FIGURE 14  
 EXAMPLE OF AN ISO-ILLUMINATION DIAGRAM  
 Voorbeeld van 'n iso-illuminasie-diagram

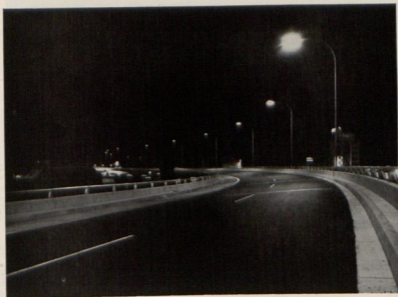


Fig. 15  
 Streetlighting Installation Sivewright-Berea Motorway, Johannesburg  
 Straatlig-installasie Sivewright-Berea-Motorpad, Johannesburg



Motorway on which luminance and illumination measurements were made by the Bureau shortly before it was opened to traffic.

The classification of this road according to the proposed code is A<sub>1</sub>. It is lighted by cut-off, sodium luminaires in a staggered and single side arrangement. The mounting height is 35 feet, overhang 6 feet and the distance between consecutive luminaires is 104 feet.

A very interesting feature of this test is the comparison obtained between the luminance of an asphaltic section and a section with a concrete surface on one of the on-ramps, where both sections had the same average illumination.

Figure 16 shows a photograph of the asphaltic part of the road.



Photograph of the Road Surface

Fig. 16

Foto van die oppervlakte van die pad

The results obtained are tabulated in Fig. 17.

The importance of the reflecting properties of the road surface in streetlighting is clearly illustrated by the results. Note that the average luminance from the lighter concrete surface is more than twice that from the asphaltic surface with the same illumination level. The results also give an indication of the terms "medium" and "light" coloured road

motorpad, waar die Buro lig- en illuminasiemettings gedoen het kort voordat die pad vir verkeer oopgestel is.

Hierdie pad is ooreenkomstig die voorgestelde kode as A<sub>1</sub> geklassifiseer. Dit word verlig deur middel van natrium armature van die afsny-tipe, wat net aan die een kant van die pad en in verspringende rangskikking aangebring is. Die monterhoogte is 35 voet, die oorstek 6 voet en die afstand tussen opeenvolgende armature 104 voet.

'n Baie interessante kenmerk van hierdie toets is die vergelyking tussen die luminasie van 'n geteerde gedeelte en 'n gedeelte met 'n beton-oppervlakte op een van die opritte, waar albei gedeeltes dieselfde gemiddelde illuminasie gehad het.

Figure 16 toon 'n foto van die geteerde gedeelte van die pad.

Die resultate wat verkry is, word in figuur 17 getabuleer.

Die belangrikheid van die weerkaatsende eienskappe van die pad-oppervlakte, vir sover dit straatverligting aanbetref, word duidelik deur hierdie resultate weerspieël. Dit is opmerklik dat die gemiddelde luminasie van die ligter beton-oppervlakte meer as tweemaal soveel is as dié van die teeroppervlakte by dieselfde illuminasiepeil. Die resultate gee ook 'n

Fig. 17

## Summary of Results Obtained

	Asphaltic surface on straight section of road	Asphaltic surface on on-ramp	Concrete surface on on-ramp
Average luminance cd/sq. ft.	0.30	0.30	0.74
Average illumination, lumens/sq. ft.	1.24	1.88	1.88
Luminance uniformity, $\frac{\text{max.}}{\text{min.}}$	3:1	4:1	3:1
Illumination uniformity, $\frac{\text{max.}}{\text{min.}}$	5:1	4:1	4:1
Average illumination			
Average luminance	13:1	20:1	8:1

surface used in the code. The ratio of average illumination to average luminance is 13:1 for the asphaltic surface on the straight portion of the road which in terms of the code is the ratio for a light coloured surface if cut-off luminaires are used. The ratio for the concrete surface is 8:1 which means that it is somewhat better than a light coloured surface. The ratio of 20:1 found on the asphaltic portion on the on-ramp is not a true reflection of the illumination ratio of the surface because it is on a luminance part of the ramp where there is considerable horizontal curvature and the luminance of only a small number of points could be measured. The ratio obtained on the concrete surface is also subject to this criticism for the same reason.

## 6. THE NEED FOR IMPROVED STREETLIGHTING

Information on the effect of improved streetlighting on night traffic safety is scattered through the literature and is often difficult to obtain. During 1965 a joint committee of the Institute of Traffic Engineers and the Illuminating Engineering Society was formed to collect readily available data showing effects of streetlighting on accident and crime reduction, to prepare a written report summarizing their findings and to submit this report to the United States Senate and United States House of Representatives.

The very comprehensive report prepared by this joint committee was subsequently published<sup>4</sup> and it would not be out of place to repeat some of their interesting findings in this paper.

Traffic accidents killed 47,800 persons and disabled 1,700,000 in the United States during 1964. The economic

Fig. 17

## Opsomming van resultate verky

	Teer-oppervlakte van reguit deel van pad	Teer-oppervlakte van oprit	Beton-oppervlakte van oprit
Gemiddelde illuminasie kd/vk. vt.	0.30	0.30	0.74
Gemiddelde illuminasie lumens/vk. vt.	1.24	1.88	1.88
Eenvormigheid van illuminasie, $\frac{\text{maks.}}{\text{min.}}$	3:1	4:1	3:1
Eenvormigheid van illuminasie, $\frac{\text{maks.}}{\text{min.}}$	5:1	4:1	4:1
Gemiddelde illuminasie			
Gemiddelde illuminasie	13:1	20:1	8:1

aanduiding van die betekenis van die terme "medium"- en "lig"-kleurige padoppervlaktes wat in die kode gebruik word. Die verhouding van gemiddelde illuminasie is 13:1 vir die gemiddelde illuminasie

teeroppervlakte op die reguit gedeelte van die pad, wat ingevolge die kode die verhouding vir 'n ligkleurige padoppervlakte is as die afsny-tipe armatuur gebruik word. Die verhouding vir die beton-oppervlakte is 8:1, wat beteken dat dit ietwat beter is as 'n ligkleurige oppervlakte. Die verhouding van 20:1 wat op die geteerde gedeelte van die oprit gevind is, is nie 'n getroue weergawe van die illuminasie-verhouding

luminasie van die padoppervlakte nie, omdat dit geneem is op 'n gedeelte van die pad waar daar 'n aansienlike mate van horisontale kromming teenwoordig was en waar die luminasie van slegs 'n klein aantal punte gemeet kon word. Die verhouding wat op die beton-oppervlakte verky is, is aan dieselfde kritiek onderhevig, en wel om dieselfde redes.

## 6. DIE BEHOEFTE AAN VERBETERDE STRAAT-VERLIGTING

Inligting omtrent die uitwerking van verbeterde straatverligting op die veiligheid van nag-verkeer is dwarsdeur die beskikbare literatuur versprei en is dikwels moeilik bekombaar. Gedurende 1965 is 'n gesamentlike komitee van die Instituut van Verkeersingenieurs en die "Illuminating Engineering Society" gestig met die doel om geredelik beskikbare gegewens in verband met die uitwerking van straatverligting op die vermindering van ongelukke en misdaad in te samel, om 'n verslag waarin hul bevindings uiteengesit word, voor te berei en om daardie verslag aan die Senaat en die Huis van Verteenwoordigers van die Verenigde State voor te lê.

Die baie omvattende verslag wat deur hierdie gesamentlike komitee voorberei is, is daarna gepubliseer,<sup>4</sup> en dit sal nie onvanpas wees om sekere van hul interessante bevindings in hierdie verhandeling te herhaal nie.

Gedurende 1964 is in die Verenigde State 47,800 persone in padongelukke gedood en 1,700,000 vermink. Die ekono-

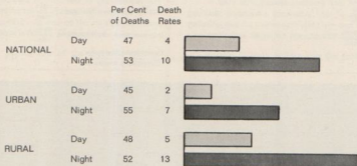
loss resulting from these figures is estimated at eight billion dollars.

About 53 per cent of the deaths occurred at night. The death rate (deaths related to vehicle miles of travel at night) is however approximately 2½ times the day rate (see Fig. 18).

miense verlies deur hierdie ongelukke veroorsaak, word op agt-biljoen dollar beraam.

Ongeveer 53 persent van hierdie ongelukke het gedurende die nag plaasgevind. Die sterftekoers (dws. sterftes in verhouding tot die aantal voertuigmyle gedurende die nag afgeleë) is egter ongeveer twee-en-'n-half keer so hoog as die koers gedurende die dag. (Sien figuur 18).

Fig. 18



Verkeerssterftes gedurende dag en nag. Syfers in 1965 vanaf Nasionale Veiligheidsraad verkry

Figure 19 shows the extent to which streetlighting can reduce night traffic deaths. The information contained in this table is based on a study made at 33 locations in the United States and 64 locations in England.

In 1945 a relighting programme commenced in Kansas City, Missouri. Figure 20 shows the decrease in the percentage of night-time pedestrian fatal accidents as the relighting programme progressed. It is estimated that 140 pedestrian lives were saved during the twelve year period.

Finally, Figure 21 which resulted from a study of fatal and injury accidents on 93 miles of major routes in Kansas City, shows that the night accident reduction on these routes increased in proportion to the level of illumination. Note that it shows no improvement on routes lighted to a level less than 0.4 lumens per square foot.

## 7. CONCLUSION

There is evidently a need for streetlighting and the potential benefits are so great that half measures cannot be justified. The proposed SABS code outlines what we believe to be sound recommendations which are within practical economic reach of local authorities. It is hoped that the code, which will

Figure 19 toon die mate waartoe straatverligting kan dien om verkeerssterftes gedurende die nag te verminder. Die inligting in hierdie tabel vervat, is gebaseer op gegewens wat op 33 verskillende plekke in die Verenigde State en op 64 plekke in Engeland ingesamel is.

In 1945 is daar in Kansas City, Missouri, met 'n herverligtingsprogram begin. Figuur 20 toon aan hoe die aantal noodlottige voetganger-ongelukke gedurende die nag afgeneem het namate daar met die herverligtingsprogram gevorder is. Daar word beraam dat die lewens van 140 voetgangers gedurende die tydperk van twaalf jaar gespaar is.

Ten slotte toon figuur 21, wat die uitslag is van 'n studie van ongelukke waarin persone gedood of beseer is op 93 myl hoofpaaie in Kansas City, dat die ongelukssyfer in die nag afgeneem het in verhouding tot die illuminasiepeil. Dit is van belang om daarop te let dat daar geen verbetering voorgekom het op paaie wat teen 'n peil van minder as 0.4 lumens per vierkante voet verlig is nie.

## 7. SLOT

Daar bestaan klaarblyklik 'n behoefte aan straatverligting, en die potensieële voordele is so groot dat daar geen regverdiging bestaan om halfhartig te werk te gaan nie. Die voorgestelde S.A.B.S.-kode maak voorsiening vir wat ons beskou as gesonde aanbevelinge wat terselfdertyd binne die praktiese

Fig. 19

REDUCTIONS IN TRAFFIC DEATHS FOLLOWING IMPROVED LIGHTING\*  
 Vermindering van verkeesterftes ná verbetering van verligting

Where lighting was installed	Night traffic deaths			
	Year before lighting	Year after lighting	Reduction in deaths	
United States				
California	---	---		
	state highway entering Hayward	6	0	6
	30 intersections in Los Angeles	11	1	10
	9.5 miles of thoroughfare in Oakland	7	3	4
Connecticut	---	---		
	31 miles of thoroughfare in Hartford	58	13	45
	main thoroughfare in West Haven	17	1	16
	7.25 miles of Berlin Turnpike	9	0	9
Florida	---	---		
	Bayshore Boulevard in Tampa	3	0	3
Illinois	---	---		
	thoroughfares in Peoria	10	8	2
Indiana	---	---		
	intersections of state and federal highways	13	1	12
	main thoroughfares in Gary	43	20	23
	three-mile stretch of U.S. 40	1	0	1
	main thoroughfares in Indianapolis	46	32	14
Maryland	---	---		
	major intersection in Baltimore	16	6	10
Michigan	---	---		
	four miles of highway entering Grand Rapids	14	3	11
	thoroughfares in Detroit	32	2	30
Missouri	---	---		
	eight main thoroughfares in Kansas City	9	4	5
New York	---	---		
	thoroughfares of Buffalo	66	27	39
	1.6 miles of main thoroughfare in Utica	3	0	3
Ohio	---	---		
	main thoroughfares in Cleveland	59	42	17
	main thoroughfares in Dayton	22	13	9
	main thoroughfares in Rocky River	8	3	5
Pennsylvania	---	---		
	six intersections of main highway in Darby	6	0	6
Tennessee	---	---		
	main thoroughfares in Nashville	19	6	13
Texas	---	---		
	bridge approaches in Dallas	2	0	2
	4.3 miles of thoroughfare in Houston	5	1	4
	main thoroughfares in San Antonio	21	0	21
Utah	---	---		
	three-mile stretch of highway entering Salt Lake City	12	1	11
Virginia	---	---		
	West Broad Street in Richmond	3	0	3
Washington	---	---		
	main thoroughfare in Seattle	2	0	2
	main thoroughfare in Spokane	5	0	5
Great Britain	---	---		
	64 lengths of road, or groups of lengths	28	15	13
	<b>Totals</b>	<b>556</b>	<b>202</b>	<b>354</b>

Reduction in Night Deaths = 64 per cent

\*Source: Street & Highway Safety Lighting Bureau, 55 Public Square, Cleveland, Ohio.

shortly be available, will be accepted and used by people concerned with streetlighting.

#### 8. ACKNOWLEDGEMENTS

The author wishes to thank the Council of the South African Bureau of Standards for permission to publish this

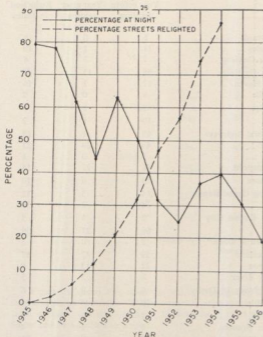
ekonomiese vermoë van plaaslike besture val. Die hoop word uitgespreek dat die kode, wat binnekort beskikbaar behoort te wees, deur al diegene wat met straatverligting te make het, aanvaar en toegepas sal word.

#### 8. DANKBETUIGINGS

Die skrywer hiervan wil graag sy dank betuig aan die Raad van die Suid-Afrikaanse Buro vir Standaarde vir hul

paper and the City Council of Johannesburg to use the results obtained on the Sivewright-Berea Motorway. He is also deeply indebted to his colleagues and to M. J. F. Dempster for their valuable collaboration.

Fig. 20

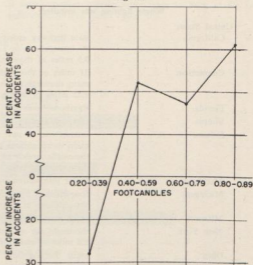


Afname in persentasie noodlottige voetganger-ongelukke gedurende die nag en toename in persentasie van strate wat herverlig is namate herverligtingsprogram in Kansas City, Missouri, gevorder het.

Decrease in percentage of night-time pedestrian fatal accidents and increase in percentage of streets relighted as Relighting Programme progressed in Kansas City Mo.

toestemming om hierdie verhandeling te publiseer en aan die Stadsraad van Johannesburg vir die vergunning om die resultate wat op die Sivewright-Berea-motorpad verkry is, te gebruik. Hy is ook baie dank verskuldig aan sy kollegas en aan M. J. F. Dempster vir hul waardevolle samewerking.

Fig. 21



Per cent change in number of night fatal and injury accidents for routes relighted in Kansas City, Mo. See Table V. Note no improvement in routes relighted to less than 0.4 footcandle.

Persentasie verandering in ongelukke gedurende nag op herverligte roetes in Kansas City. Let op dat daar geen verbetering is op roetes wat teen 'n laer peil as 0.4 kandelas per vk. vt. verlig is nie.

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## PORTABLE APPLIANCES FED FROM SOCKET OUTLETS

by A. F. TURNBULL

The definition of wiring work in the Electrical Wiremen and Contractor's Act, and the electricity by-laws of local authorities, makes it clear that the responsibility of the supplier stops at the termination of the permanent wiring of an installation. The supplier has no legal obligations or control beyond the socket outlet and a consumer is free to plug-in whatever apparatus he likes, into that socket-outlet.

In respect of portable appliances fed from socket-outlets, there are two aspects to consider, namely, hand appliances and appliances which cannot be regarded as portable.

It is becoming increasingly difficult to differentiate between "fixed" and "plug-in" installations and the extent of the responsibility of the Supply Authority's Engineer.

The Standard Regulations for the Wiring of Premises defines "Portable Appliance" as meaning, "an appliance capable of being readily moved, where established practice or the conditions of use make it necessary or convenient for it to be detached by means of a flexible cable or flexible cord and plug or lampholder plug from any source from which electrical energy is available.

**Note:** The term portable appliance is deemed to include model electric railways and other toys."

The definition of a portable Electric Hand Tool, in the Factories, Machinery and Building Work Act, "means any portable electrically operated drill, saw, grinder, planer, or other electrically operated hand tool."

Domestic hand appliances include lawn mowers, polishers, vacuum cleaners, hair dryers, kettles, irons, cake mixers, etc., also portable electrically operated hand tools.

The South African Bureau of Standards have drawn-up a series of electrical equipment safety specifications, to establish minimum safety standards, for electrical appliances. A number of these are declared to be compulsory standard specifications by Government Notice 1017, dated 3rd July, 1964, and republished in Regulation Gazette No. 567 (Notice R1615) dated 2nd October, 1965. These safety standards improve the safety of the appliance itself, but do not preclude faulty connection to a plug by an unskilled person. Consumers, also, consider they are well within their rights and the intention of the regulations by using properly installed socket-outlets to feed apparatus, such as burglar alarms, window air-conditioning units, stoves, water heaters, refrigerators, washing machines, incubators and brooders, welding machines, swimming pools, borehole pumps etc. These devices are not all covered by safety specifications and the internal wiring of certain apparatus leaves much to be desired. The G.P.O. consider that their control and extension circuits, for telephone sirens or Klaxon hooters, "cannot be regarded as permanent, as the installation and/or removal may be demanded at anytime." They consider

## DRAAGBARE TOERUSTING VOORSIEN VANUIT BUSKONTAKDOSE

deur A. F. TURNBULL

Die woordomsyning van bedradingwerk in die Elektrotegniese draadwerkers en aannemerswet en die elektriese verordeninge van plaaslike besture, maak dit duidelik dat die verantwoordelijkheid van die voorsiener by die afsluiting van die vaste bedrading van die insallasie ophou. Die voorsiener het geen wetsverpligtinge of beheer verder as die buskontakdoos nie, en 'n verbruiker is vry om enige apparaat wat hy verkies in die kontakdoos te stop.

Wat draagbare toerusting voorsien van buskontakdoos betref is daar twee moontlikhede om te oorweeg nl. hanteerbare apparaat en dié wat nie as draagbaar beskou kan word nie.

Dit word steeds moeiliker om tussen "vaste" en "instop" insallasies te onderskei en die verantwoordelijkheid van die ingenieur vir die voorsieningsowerheid te bepaal.

Volgens die Standaard-Regulasies vir die Bedrading van Persele beteken "verplaasbare toestel", "n toestel wat maklik verplaas kan word, waar gevestigde gebruik of die gebruiktoestande dit nodige of gerieflik maak om dit en enige bron waarvandaan elektriese energie verkry word, te kan afsny deur middel van 'n buigbare kabel of koord en stopkontak of lamphouerstoptoktak.

**(Let Wel:** onder die uitdrukking "Verplaasbare toestel" word ook elektriese modelspoorweë en ander elektriese speelgoed verstaan").

In die Wet op Fabriek, Masjinerie en Bouwerk word "draagbare elektriese handgereedskap" omskrywe as "enige draagbare elektriese aangedrewe boor, saag, slyper, skaaf of ander elektries aangedrewe handgereedskap". Huishoudelike handtoestelle sluit in grassnyers, poleeders, stofsuikers, haardroërs, ketels, strykkysters, kosmengers, ens. ens. en ook draagbare elektries aangedrewe handgereedskap.

Die S.A. Buro vir Standaarde het 'n aantal veiligheidspesifikasies vir elektriese apparaat opgestel ten einde minimum veiligheidstandaarde vir elektriese apparaat daar te stel. 'n Aantal van dié is tot verpligte standaardspesifikasies verklaar in staatskennisgewing 1017 van 3 Julie 1964 en herdruk in regulasiekoerant No. 567 (kennisgewing R1615) van 2 Oktober 1965. Hierdie veiligheidsstandaarde verhoog die veiligheid van die apparaat self maar skakel nie 'n foutiewe aansluiting aan die stopkontak deur 'n onbevoegde persoon uit nie. Verbruikers is ook van mening dat dit hulle reg is en binne die bedoeling van die regulasies is om vanuit behoorlik geïnstalleerde buskontakdoosse apparate aan te sluit soos diefalarms, venster-tipe van lugreëling, stowe, waterverwarmers, yskaste, wasmasjiene, broeikaste, swismasjiene, swembaddens, pompe op boorgate ens. Hierdie apparate is nie almal deur veiligheidspesifikasies gedek nie en die binnebedrading van verskeie apparate laat baie te wense oor. Die H.P.K. is van mening dat hulle beheer en verleningstroombane na telefoon-sirenes en Klaxon nie as permanent beskou kan word nie "aangesien die instalasie of verwydering te enige

such installations to comply with the definition of "Portable Appliances" of the Standard Wiring Regulations.

The 1966 Amendments to the Standard Regulations for the Wiring of Premises require towel-drying rails and radiators, mounted in a bathroom, to be installed as part of the fixed wiring. Special earthing is, also, now required for Fixed Washing Machines and Dishwashers, stoves, water heaters and garbage Disposal Units installed within six feet of a water tap.

The recommendation committee for the A.M.E.U., for New Electrical Commodities, approve certain apparatus suitable for use, provided it is installed as part of the fixed wiring.

The majority of electrocutions is attributed to portable appliances and there is a tendency to reduce the number of "plug-in" installations permitted.

The obvious solution to the problem of safe use of portable appliances fed from socket-outlets, is the installation of approved earth-leakage devices. Local Authorities, with operational experience with earth-leakage devices installed for the whole installation, find there is a high incidence of "nuisance tripping" due to, primarily, the inherent and relatively high, though harmless, leakage currents escaping from stove elements. It is, also, difficult to pin-point a neutral fault, which, also, would cause a relay to operate, as the neutral conductors of all sub-circuits invariably are solidly connected. (Double-pole isolation of all sub-circuits would facilitate tracing of such faults.) Fluorescent lighting circuits sometimes caused spurious operation of relays. The leakage current of a fluorescent ballast may be considerable.

The sensitivity and frequent spurious tripping of an earth-leakage device, for no obvious reason, leads the consumer and more than often the electrical contractor called upon to remedy the fault, to believe that the earth-leakage device is faulty. An excessive number of consumer complaints result if the earth-leakage device is installed and maintained by the Local Authority. Local Authorities, therefore, hesitate to install earth-leakage devices on their main point of supply to a consumer.

The Factories, Machinery and Building Work Act places the responsibility of providing an earth-leakage device or other approved protection upon the user of the apparatus. The installation and maintenance of earth-leakage devices for portable appliances fed from socket-outlets must, in the same way, be made the responsibility of the user and not the Local Authority.

(The problems associated with pump installations in particular are set out in an annexure).

tyd ge-eis mag word." Hulle meen dat sulke installasies voldoen aan die woordomskrywing van "verplaasbare toestelle" in die Standaard Bedringsregulasies.

Die 1966 wysigings van die Standaard Regulasies vir die Bedrading van Persone vereis dat verwarmers en handdoekdroërs in badkamers as deel van die vaste bedrading geïnstalleer moet word. Spesiale aarding word ook nou vereis vir vaste wasmasjiene en skottelgoedwassers, stowe, waterverwarmers en afvalontbinders wat binne ses voet van 'n waterkraan geïnstalleer is.

Die aanbevelingskomitee van die V.M.E.O. vir nuwe elektriese kommoditeite keur sekere apparaat vir gebruik goed mits dit as deel van die vaste bedrading geïnstalleer word.

Die meeste van die noodlottige elektriese ongelukke kom voor op verplaasbare apparate en die neiging is om die aantal instop-installasies te beperk.

Die ooglopende oplossing vir die probleem vir die veilige gebruik van verplaasbare apparate voorsien van buskontaktdose lê in die gebruik van aardlektroering.

Plaaslike besture wat ondervinding het van die gebruik van aardlektroering vir die hele installasie, vind dat 'n groot aantal van lastige onderbrekings plaasvind. Dit word hoofsaaklik toegeskrywe aan die betreklik hoe dog onskadelike strome wat van die stoelelemente normaalweg uitlek. Dit is ook moeilik om 'n fout op die neutrale geleier wat 'n relê sal laat werk te bepaal aangesien die neutrale geleiers op alle sub-stroombane gewoonlik saamgekoppel is. (Dubbelpolige skakeling op alle sub-stroombane sal die bepaling van sulke foute vergemaklik.)

Stroombane vir fluoressensieverligting veroorsaak ook soms foutiewe werking van relê's. Die lekstrome op ballaspoele mag soms aansienlik wees.

Die gevoeligheid en lastige onderbrekings van aardlektrelê's, dikwels vir geen sigbare rede nie, laat die verbruiker en ook die elektriese aannemer wat ingeroep word om die fout te herstel, meen dat die aardlektapparaat defektief is.

'n Oormatige aantal verbruikersklagtes sal die gevolg wees as aardlektapparaat deur die Plaaslike Bestuur voorsien en geïnstalleer word. Plaaslike Bestuur is dus huiwerig om aardlektapparaat op die hooftoevoerpunt van die verbruiker aan te bring.

Die Wet op Fabriek, Masjinerie en Bouwerk plaas die verantwoordelijkheid om 'n aardlektapparaat of ander goedgekeurde beveliging aan te bring op die gebruiker van die toestel. Die installerende en instandhouding van aardlektapparaat vir verplaasbare toestelle voorsien vanaf buskontaktdose moet desgeliks die verantwoordelijkheid van die verbruiker gemaak word en nie die van die Plaaslike Bestuur nie.

('n Aanhansels wat die probleme met betrekking tot pompinstallasies volledig toelig word aangeheg).

## DOMESTIC PUMPING INSTALLATIONS FOR SWIMMING POOLS AND BOREHOLES

### 1. BY-LAWS AND REGULATIONS:

The above mentioned type of installation is possibly of concern to most Local Authorities.

Electricity By-Laws generally provide, "that any installations connected or about to be connected with the service mains shall be provided and fixed and maintained at all times in safe working order by the consumer or owner at his own expense, in accordance with these by-laws and the wiring regulations. No person, other than an authorised official shall, directly or indirectly connect or attempt to connect any installation or part thereof with any service mains."

The onus is therefore, on the consumer to observe compliance with the electricity bylaws and wiring regulations in respect of any alterations or extensions to an electrical installation. The consumer if he proceeds with unauthorised connections does so at his own risk and responsibility.

### 2. SWIMMING POOLS AND BOREHOLES:

The advent of the private swimming pool, and latterly on account of the water restrictions, the borehole, and the availability to the public of the so called "plug-in" packaged filtering and pumping units, has accentuated the need to provide for this type of installation. Local Authorities cannot indefinitely plead ignorance to the existence of these installations, because the consumer, who more often than not is unaware of the implications, fails to report such installations.

### 3. VEREENIGING INSTALLATIONS:

In Vereeniging, the Building By-laws do not require plans to be submitted to the Council for a swimming pool; unless changerooms and other structures are erected in association therewith. Very few swimming pool electrical installations have been inspected by the Council. There must be many others which have not been inspected. The Council between 1946 and 1966 approved 186 boreholes, the majority of these applications were received since the water restrictions were imposed early in 1966. Since then applications to sink boreholes have averaged 10-15 per month. Relatively few borehole electrical pumping installations have been inspected. Whether or not, all applications to sink boreholes have in fact been accomplished is not known.

### 4. TYPES OF INSTALLATION:

Most pumping units for swimming pools and boreholes require single phase electric motors ranging from  $\frac{1}{4}$  horse power to 2 horse power. On account of the expense in constructing a pool or sinking a borehole, the tendency is to

"do-it-yourself" in respect of the pumping installations. Complete self-contained packaged filtering plants or components are readily available. These installations are connected by flexible cables to the nearest socket-outlet on the fixed installations for the premises. Most domestic premises are wired for single phase supply, three phase pumps installations usually do not constitute a problem.

Swimming pools and boreholes are not short term investments. Whilst original installations may be reasonably safe, can these installations endure, for the life of the asset?

### 5. ELECTRICAL WIREMEN AND CONTRACTORS ACT

Consumers driven by the economics of providing for swimming pools and boreholes, and advised by "experts" who are concerned mainly with the selling of the plant and components seek refuge in the definition of "Wiring Work", in the Electrical Wiremen's Act and Regulations (Act No. 20 of 1939 as amended). This definition for convenience is quoted in full as follows:-

"Wiring Work" means the installation, alteration repair or testing of any cable, conductor, fitting, apparatus or conduit in or connected to such premises, but does not include any used for purposes incidental to the supply of electricity from a distribution line of any supplier to a point of consumption in or connected to such premises, but does not include any such work on —

- (a) any transmission, distribution or service line or service apparatus of the supplier;
- (b) any cable, conductor or fitting for the supply of current to any electrical appliance from a point of outlet at which the fixed wiring in or connected to any premises terminates;
- (c) any cable, conductor, fitting, apparatus or conduit connected or intended to be connected to a supply system the pressure of which is normally less than 40 volts;
- (d) any cable, conductor, fitting, apparatus or conduit which constitutes machinery as defined in section one of the Mines and Works Act 1956, (Act No. 27 of 1956);
- (e) any cable, conductor, fitting or conduit used or intended to be used in connection with any telegraph or telephone apparatus or radio circuit; or
- (f) any fuse-wire,  
Nor does it include any cutting of holes or chases in floors and walls or the cutting or thread screwing of conduits or work of a similar nature.



## 6. FACTORIES MACHINERY AND BUILDING WORK ACT

In this Act, machinery is defined as follows:

"Machinery" means —

- (a) any locomotive or any stationary or portable engine or boiler or other steam apparatus;
- (a) bis any pressure vessel or portable gas container;
- (b) any appliance or combinations of appliances used for generating, developing, receiving, storing, converting, transforming or transmitting any form of power or energy, or for conveying persons or goods; and
- (c) any other appliance that the Minister may by notice in the Gazette declare to be machinery for the purposes of this Act, but does not include —
  - (i) machinery as defined in the Mines and Works Act, 1956 (Act No. 27 of 1965);
  - (ii) domestic appliances in use as such; or
  - (iii) vehicles other than steam driven vehicles;
  - (iv) machinery situated in the danger area of an explosives factory as described in the regulations made under Explosives Act, 1956 (Act No. 26 of 1956).

Provided that all electrical domestic appliances shall be deemed to be machinery for the purposes, of sections Thirty-one, Thirty-two and Thirty-three.

The point of issue is whether or not a plug-in motor is "machinery" any more than does a domestic washing machine, which very often is permanently connected to water and drainage systems.

## 7. DOMESTIC WATER PUMPING INSTALLATIONS

Borehole Domestic water pumping installations comprise two types. The one type is where the electric motor is on the surface and the pump is driven by direct connection to the motor or by belt drive. The other type is the submersible unit where pump and motor is submersed in the borehole.

Single phase and three phase units for both types of installation are common.

## 8. PERMANENT INSTALLATIONS

When a consumer has applied for permanent supply for pump installations:-

- (a) The surface type of installation is straight forward and complies with the Standard Regulations for the Wiring of Premises and the Factories Machinery and Building Work Act. Solid earthing connected to an earth electrode and main earth lead for the premises is required. A separate earth continuity conductor is required between the control switchgear and the motor. The S.W.A. of P.V.C. insulated, P.V.C. sheathed cable is permitted to be used as earth continuity conductor in accordance with Table 1—attached.

- (b) The submersible type of pumping unit presents a problem. These units come equipped from the factory with a length of flexible cable. A three core cable is provided for three phase motors. Three basic submersible motor construction are:-

- (i) All wet motors in which the winding wire is covered with a waterproof insulation and the windings operate directly in water.
- (ii) Oil filled motor in which the entire motor is filled with insulating oil.
- (iii) Motors with hermetically sealed stator, in which the windings are completely sealed in an all welded stainless steel case.

The motors themselves are adequately insulated.

The complete unit motor and pump is suspended in the borehole by the rising pumping column, which is secured by a clamping device resting on the borehole casing. The supply cable is clamped to the steel pipe down the borehole. Earth continuity is provided by earth bends between the pump column, borehole casing and contact switchgear.

## 9. EARTHING REQUIREMENTS

The Vereeniging Electricity Undertaking has found by experience, that pipe fittings may result in the loss of an earth continuity bond due to high resistance joints in the pipe fittings, the borehole casing is often bitumen coated, and high resistance of soil and water cannot be relied upon for an adequate earth. Cases are on record where the consumer removed the earth bonds to work on the pump or pumping column and the whole installation subsequently became alive with fatal results. Vereeniging therefore requires a separate earth continuity conductor to be incorporated in the supply cable to the submersed motor or sensitive core balance earth leakage to be provided where solid earthing is not possible.

This requirement raised a storm from consumers and the suppliers of submersible pumps. The complaints are that the submersible pumping units are imported with the special supply cable attached and that a fairly high capacitance leakage may take place due to the close proximity of the submersible pump motor windings with the earthed media, rendering earth leakage relays ineffective.

It has been ascertained that the special supply cable is a flexible all rubber filled cable to avoid soaking up of moisture, a thicker sheath than usual, better grade of rubber smooth and perfectly round. Strictly there is no B.S. or S.A.B.S. recommendations for cables which are intended for immersing in water when connected to a submersible pump.

This special cable can be made in the Republic with an earth continuity conductor providing reasonable quantities are ordered. There is, however, considerable delay in manufacture.

## 10. HOUSING:

Another problem associated with pumping installations generally is the housing for motors, switches etc. These are not covered by Building By-laws. Consumers adopt a wide

and varied method for protecting pump installations. The submersible pump requires accommodation only for switch control gear. The surface type installation requires protection for motor, machinery and control gear. Consumers provide accommodation which may be half oil drums, packing cases, sacks, canvas covers, steel boxes, sumps, and a more popular and recent innovation the pre-fabricated asbestos dog kennel.

The Vereeniging Electrical Department requires:-

- (1) Every electric motor to be controlled by an efficient switch for starting and stopping. Such switch to be readily accessible and easily operated and so placed as to prevent danger.
- (2) The type of appliance used for raising water, together with the type of prime mover, the type of storage installation and the building or other structure housing the pumping equipment, shall be approved by the Council.

Such building or structure must be:-

- (i) firmly attached to its foundation by holding bolts or other approved means;
- (ii) water tight;
- (iii) kept locked to prevent any person or animal being injured by the machinery and/or other installations.

## 11. CONCLUSION

These then are the problems in respect of domestic pumping installations which should be considered from the point of uniformity of installation by all local authorities.

**TABLE: Maximum permissible length of cable, where steel wire armouring is used as earth continuity conductor**

Nominal Area of Conductor sq. in.	Twin feet	Three Core feet	Four Core feet
0.003	89	95	139
0.007	142	162	171
0.01	162	176	272
0.0225	166	300	333
0.04	300	333	460
0.06	333	460	545

**Based on:**

- (1) B S3346: 1961 Table 25 — Armour Resistance 660/1100 Volt cables.
- (2) Circular Conductors of equal area.
- (3) Maximum permissible earth continuity resistance 0.2 ohms.

# SENSITIVE CORE-BALANCE EARTH-LEAKAGE PROTECTION APPLIED TO OVERHEAD LINES ON HIGH-VOLTAGE SYSTEMS

H. P. SMITH, B.Sc. (Eng.), A.M. (S.A.) I.E.E.

## INTRODUCTION:

Electrical Engineers have long felt the need for protective equipment to provide complete protection against the hazards caused by leakages to earth on H.V. overhead line distribution systems.

It is generally agreed that the present earth-fault protective systems employed are not sensitive enough to provide adequate protection to life and property under "dropped-line" conditions. Persons and farm animals are electrocuted and grass fires are caused in the vicinity of a dropped line without the earth-leakage relay having operated, the fault current drawn under these conditions being insufficiently high to cause operation of the protective equipment.

The purpose of this paper is to offer a possible solution to this protection problem.

## SCOPE:

This paper is confined to a consideration of sensitive earth-leakage protection of overhead lines operating at a maximum system voltage of 11 kV and a minimum of 2.2 kV.

## 1. CONDITIONS TO BE SATISFIED BY PROTECTIVE RELAYS:

**RESPONSE:** The sensitivity and response time shall be such that there is no danger to life and property under dropped line conditions.

**PHASE FAULT STABILITY:** The relay must not respond to through-faults (phase to phase) of magnitude up to the maximum short circuit current fault capacity of the system being protected, and sustained for the time required by the overcurrent and short circuit protective equipment to clear the fault.

**TRANSIENT STABILITY:** The relay must not respond to transient leakage to earth inherent in an overhead line distribution system when energising or de-energising the line.

**STEADY STATE STABILITY:** The relay must not respond to the steady-state earth-leakage current inherent in an overhead line distribution system under healthy conditions.

## DISCRIMINATION ON TRANSIENT HIGH-ORDER EARTH FAULTS:

The response of the relay to be such that transient earth-faults due to lightning strikes, surges etc., are permitted to be cleared by lightning arrestors, or auto-reclosers on the first high speed trip of the recloser cycle, without the relay operating.

## DISCRIMINATION ON SUSTAINED EARTH-FAULTS:

In a system where spur feeders are employed a sustained high order earth-fault on a particular spur line should cause the spur protective fuse to blow before the earth-leakage relay operates.

## 2. ESTABLISHING VARIOUS CONDITIONS:

### RESPONSE:

Preliminary tests were conducted in January/February, 1967 in order to establish the value of earth-fault current flowing under dropped line conditions.

Figure 1 shows a C.R.O. recording of the earth-fault current with a dropped line on a 2.2 kV system. The magnitude is of the order of 1.1 amperes. The ground was dry, there having been no rain in the area for about two weeks. Slight scorching of green grass was evident after about 5 seconds of fault condition.

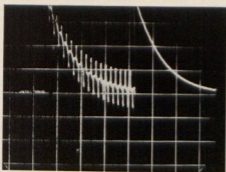


Fig 1

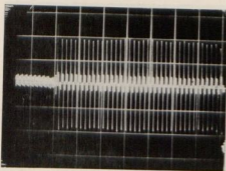


Fig. 2

Figure 2 is a recording of earth-fault current when switching in on an 11 kV system with dropped line. The steady state current magnitude was in excess of 20 amperes. The ground was sodden, there having been soft steady rain in the area for almost twelve hours before the tests.

Figure 3 shows the dropped line whereas Figure 4 shows the scorched condition of the green grass after four closing shots each of about  $\frac{1}{4}$  second duration.

It is evident from these preliminary tests that the relay must respond to an earth-fault current below 1 ampere, and the definite minimum time should be below 0.5 second.

#### PHASE FAULT STABILITY:

From a knowledge of system parameters, the available short-circuit fault levels may be established and relays designed for stability on phase faults up to available fault capacity of the system.

#### TRANSIENT STABILITY:

Figure 5 shows the earth-fault transient during energising of a healthy 2.2 kV overhead line, 2 $\frac{1}{2}$  miles long fed by 3,000 feet of 0.1 sq. inch 3 core cable. It is noted that the transient duration is 40 milliseconds.

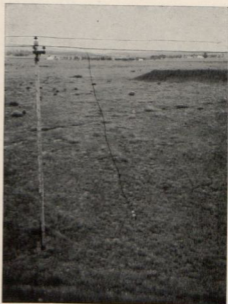


Fig. 3



Fig. 4

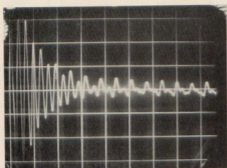


Fig. 5

Figure 6 shows the earth-fault transient during energising of a healthy 11 kV overhead line  $\pm$  3 miles long, fed by 4,000 feet of .06 sq. inch cable. Transient duration is 150 milliseconds.

On de-energising each of the above lines, the transient lasted for about 5 and 10 milliseconds respectively.

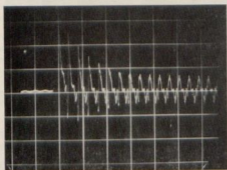


Fig. 6

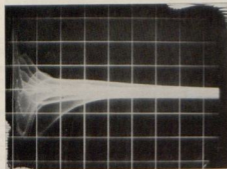


Fig. 7

Figure 7 shows an interesting transient earth fault condition. This occurred when the neutral earthing compensator which is used to provide the star point for the 2.2 kV system under test, was switched on to the already energised system.

The transient duration in this case was about 3 seconds. The initial peak is of a magnitude in excess of 500 milliamperes. A similar condition could arise when closing the incoming supply to a switchboard, where the earthing compensator is already connected to the busbars.

#### STEADY STATE STABILITY:

Figure 8 shows the steady state earth-leakage current on the 2.2 kV system with connected load at the end of the 2½ mile transmission line and loads in parallel with the line (as shown in Appendix). The leakage current is of the order of 100 milliamperes.

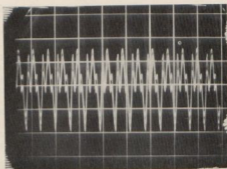


Fig. 8

Figure 9 is the steady-state earth-leakage current on the 11 kV 3 mile long overhead line with two small consumers drawing load via step-down transformers.

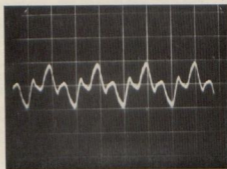


Fig. 9

Figure 10 is the steady state leakage on an 11kV line approximately 6 miles long with two small consumers as before.

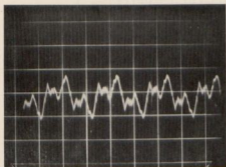


Fig. 10

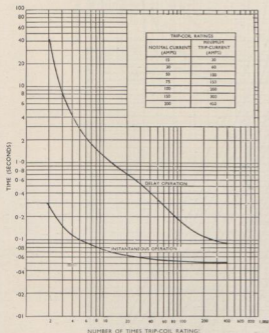


Fig. 11

In both of the above cases the leakage is of the order of 25 milliamperes.

From steady state leakage considerations only, it would appear that a relay with a nominal sensitivity of 500 milliamperes would be suitable.

Layouts of systems and methods of conducting tests and evaluating results are given in Appendix to paper.

## DISCRIMINATION ON TRANSIENT AND SUSTAINED EARTH-FAULTS

Considering a typical automatic circuit recloser cycle (we have used the Reyrolle Type OYT as an example) with a sequence of instantaneous trip, 1 second open, instantaneous trip, 1 second open, time-delay trip, 1 second open, time-delay trip and lock-out, we reproduce below in Figure 11, the time/current characteristic curves (tolerance  $\pm 20\%$ ) for instantaneous operation and delay operation.

Figure 12 shows typical time/current curves for 11 kV fuse elements (Johnson and Phillips Type D).

By correct co-ordination of the recloser characteristics and spur line fuse current-time curves shown above, it is possible to discriminate on high order earth-faults.

Using the aforementioned recloser cycle, the first instantaneous trip-operation will clear the majority of transitory faults (lightning arrestors taking care of very short-duration high current surges), and the second backs this up. It also gives a second chance to clear faults due to multiple lightning strikes and for foreign bodies to fall clear.

The first time-delayed trip of the recloser is intended to be of sufficient duration to enable spur fuses on the faulty section of line to blow, and the second is an extra safeguard since in some cases accurate discrimination cannot be assured.

Ideally, the sensitive earth-leakage relay will take care of low order earth-leakage currents (due to dropped lines mainly) of value below the minimum operating current of the recloser or spur fuse. At the same time, the relay will permit the first and second high speed trip of the auto-recloser and isolation of the fault by the spur fuse during the time-delay operation of the recloser. The latter will be on high order earth faults.

### 3. MEANS OF MEETING ABOVE CONDITIONS

After studying the above conditions, it is evident that an earth-leakage relay having an inverse and definite minimum current/time characteristic is required.

The inception (nominal) current sensitivity of the relay to be low enough to sense the permanent low order faults caused by a dropped line on dry terrain where high earth resistances prevail.

The definite minimum time to be sufficiently fast to afford protection to life and property while at the same time permitting the aforementioned devices to beat the relay in clearing the fault should it be of a transient nature, or, if on a spur line, permit its protective fuse to clear a high-order fault.

A series of relays approaching these characteristics have been designed and performance curves are shown in Figure 13.

These standard relays, are, at present being used to provide back up discriminative protection to instantaneous core-balance relays of 250 milliamperes sensitivity in low voltage distribution systems in mining and industry.

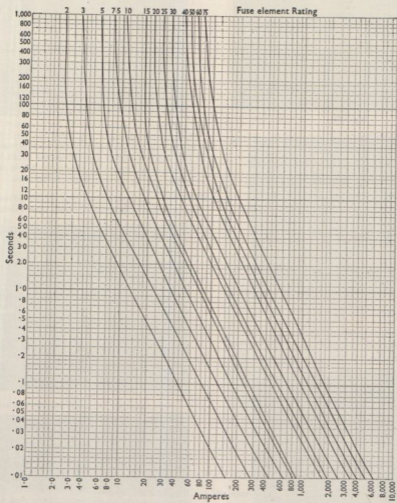


Fig. 12 FUSE CHARACTERISTICS

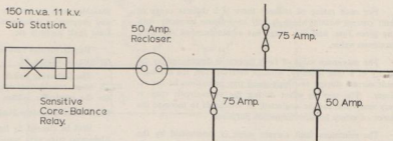
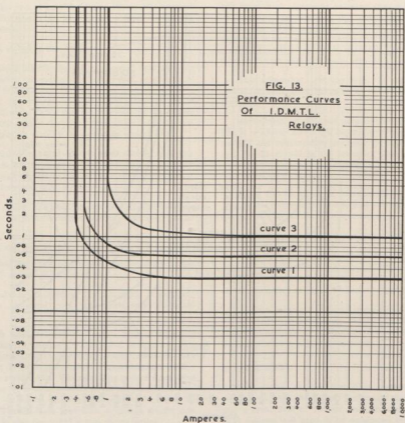


Figure 14 shows a typical H.V. overhead rural distribution system with spur feeders to consumers, and sensitive earth leakage protection at the substation.

**FIG. 14. Typical 11 K.V. Rural System.**

Figure 15 shows co-ordination curves of recloser, spur-fuses and the existing standard time-delay core-balance response times (including allowance for clearing time by sub-

station circuit-breaker — from instant at which shunt trip is excited to clearing of fault).



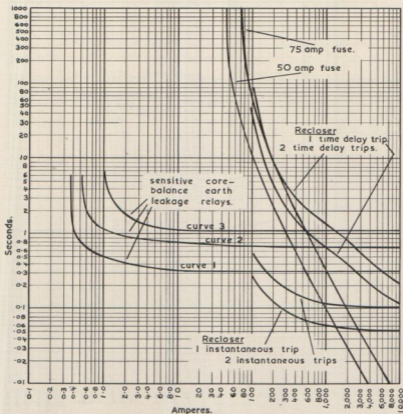


FIG. 15. Co-Ordination Curves

For each rating of recloser there is a definite range of fault current within which it will co-ordinate correctly with any given fuse, and this range has a minimum as well as a maximum value.

The maximum value of fault current is determined by the ability of a fuse to carry, without deterioration, the through-fault current during two high-speed trip operations of the recloser. The cooling effect during the open-circuit time is very small and can be neglected, as this tends to increase the factor of safety for discrimination purposes.

The minimum fault current value is determined by the ability of the fuse to clear fault currents of low magnitude before the recloser locks open after the final time-delay trip.

In calculating the fault current which a fuse can pass without deterioration, the total heating obtained must not exceed 75% of the heat needed to melt the fuse element at normal ambient temperature. This factor allows for operating

variables such as ambient temperatures, degree of preloading and progressive deterioration due to carrying successive transient fault currents etc.

This factor has been employed in plotting the fuse characteristics in Figure 15.

The following points are evident from a study of Figure 15, when considering operation under earth-fault conditions for the particular system chosen:-

#### High Order Transient Faults due to Lightning or Surges:

Will be cleared by lightning arrestors or recloser on first highspeed trip, with possibility of spur fuses blowing.

#### Earth-faults of 100 to 1,000 Amperes:

If transient in nature, cleared by recloser on high speed trip.

If sustained and between 500 and 1,000 amperes — cleared by spur fuses.

From 100 to 500 Ampères fault current, the "Curve 1" earth-leakage relay would beat the fuses, 100 to 350 ampères — "Curve 2" relay beats fuses and "Curve 3" beats fuses from 100 to 300 ampères.

#### Earth-faults of 1 to below 100 Ampères:

From the initial tests conducted on dropped lines we have seen that, depending on system conditions and ground resistance, the earth fault current could be from 1 ampère up to a value exceeding 20 ampères. Under these conditions, it is seen that the recloser will not operate, nor will the spur fuses melt. It is in this region that the sensitive earth-leakage relays come into play to provide the necessary protection.

It is appreciated that the value of fault current will vary with the position of the fault on the network and the spur fuse ratings as well as that of the reclosers will be chosen to suit load conditions and fault levels.

The above system has been chosen as a typical example to illustrate how earth-fault discriminative protection may be achieved.

#### DESCRIPTION OF PROPOSED PROTECTIVE RELAY

The proposed sensitive core-balance earth-leakage relay is described with reference to Figure 16.

The core-balance transformer (1) comprises a high-permeability super mu-metal core with multi-turn secondary winding.

Under earth fault conditions an e.m.f. is induced in the secondary winding of the core. This e.m.f. is applied to a full-wave rectifying circuit comprising two silicon diodes (2), and the resultant direct-current charges a tantalum capacitor (3) through a series resistor (4). The operating coil of a sensitive polarized release (5) is connected in series with a silicon controlled rectifier (6) to the positive and negative terminals of the capacitor. The S.C.R. is fired from a voltage divider network (7) which is also connected across the capacitor.

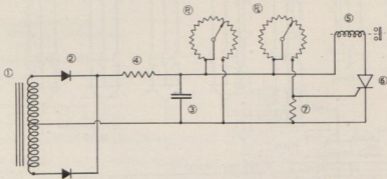


FIG. 16. - Circuit Diagram of Sensitive Core-Balance Relay.

At the inception of the earth-fault current, the capacitor will develop an increasing potential over a period determined by the fault current until this potential is high enough to trigger the S.C.R. and thus cause the energy stored in the capacitor to discharge across the coil of the polarized release, a spring loaded armature of the latter closing a pair of contacts in circuit with the shunt trip of a H.V. circuit-breaker.

The adjustable potentiometers  $P_1$  and  $P_2$  provide the means for calibrating the relay to obtain the desired tripping characteristic.

Adjustment of ( $P_2$ ) will determine the necessary voltage that is to appear across the capacitor (3) before the S.C.R. will conduct and then operate the relay (5). The higher this voltage, the slower will be the operating time of the relay. This adjustment, therefore, establishes the time characteristic of the current-time curve.

Since ( $P_1$ ) is merely a "bleed-off" potentiometer, it will provide the adjustment necessary to calibrate the relay for the current portion of the current-time curve.

#### CONSTRUCTION:

The relay would comprise two elements — a core-balance current-transformer with primary insulation for 11 kV, and a separate panel-mounting moulded enclosure housing the timing circuit, polarized release and contact assembly.

In service, the core-balance transformer would be mounted in the substation switchgear panel, with the insulated cable tails of the H.V. cable feeding the overhead line, passing through the bore of the transformer.

#### CONCLUSION:

The author realizes that it is premature to draw firm conclusions from the meagre test results already obtained, and that a great deal of further research and extensive tests on H.V. systems will need to be conducted before the technique

is definitely proven. The final response curves of the earth-leakage relays could well vary from those of the presently suggested units.

The initial results, as well as the flexibility of the relay timing mechanism do, however, hold great promise for an effective future protection scheme for dropped conductors on H.V. overhead line distribution systems.

#### ACKNOWLEDGEMENT:

The author wishes to express his thanks to his colleagues — Mr. M. R. Marot and Mr. J. A. Pryke for their assistance in compiling this paper, and Messrs. A. Reyrolle (S.A.), A.E.I. (S.A.), and Johnson and Phillips (S.A.) for permission to publish information on their reclosers and fuses.

A special word of thanks to the Management and Electrical Engineering Staff of New Springfield Colliery and Vanderbijlpark Municipality for the facilities provided to the author and his colleagues to enable the tests to be conducted.

#### APPENDIX TESTS AT GROOTVLEI

The tests were conducted on the 2.2 kV system at New Springfield Colliery, Grootvlei. The layout of the system is shown in Figure 17 below.

Earth-fault current is limited to 300 amperes by means of the compensator and current-limiting reactance in the neutral. Load was being drawn on two of the other circuits in parallel with the one on which tests were conducted.

A 250 milliampere instantaneous, as well as a 375 mA (nominal) i.d.m.t.l. relay were placed in the compensator neutral to earth connection as shown.

The C.R.O. trace represents the secondary E.M.F. appearing across a single-turn secondary of the core of the 250 mA relay and, therefore, bears a direct relationship to the induction of the core, as well as the primary earth-leakage current causing this induction.

The mag-curve of the super mu-metal core employed in the 250 mA relay having been closely measured, one is able to ascertain the primary excitation current.

#### Notes on C.R.O. Figure 1 — Steady State Leakage.

A length of 15 feet of 0.1 sq. inch bare copper conductor was laid on the ground. Another length of 0.1 sq. inch bare copper conductor was connected — one end by means of a Crosby clamp to one phase of the 2.2 kV overhead line, the other end was attached to the hook end of an insulated link stick. The line was energised and after about 15 seconds the conductor attached to the link stick was touched on the conductor laid on the ground. The resulting C.R.O. trace is shown in Figure 1.

Time base — 100 milliseconds per c.m.

Y deflection — 0.05 Volts per c.m.

Using the same time-base and Y deflection settings of the C.R.O. and the same 250 mA relay as used in the tests at Grootvlei, a primary current was passed through the bore of the relay and its value was increased until a similar trace to that obtained on site, was recorded. This is shown in Figure 18.

The r.m.s. primary current is 1.12 amperes.

#### C.R.O. Figure 5 — Transient Leakage on Energising 2.2 kV Line.

Healthy line — without dropped conductor.

Time base — 10 milliseconds per c.m.

Y deflection — .05 Volts per c.m.

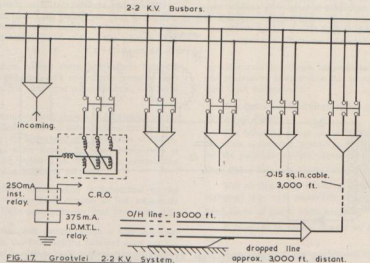


FIG. 17. Grootvlei 2.2 K.V. System.

dropped line approx. 3,000 ft. distant.

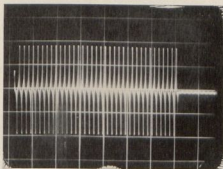


Fig. 18

On instant of closing there appears a zero phase sequence component of current in the neutral earthing conductor at a frequency of 300 cycles/second.

The amplitude peak to peak is:-  
 $6.2 \times 0.05 = 0.31$  Volts.

Since this represents the core induction at 6 times the fundamental 50 cycle frequency, we may, as a first approximation, assume that for a fifty cycle current, the peak to peak induced voltage to be:-

$$\frac{0.31}{6} = 0.052 \text{ Volt.}$$

This represents an r.m.s. induced voltage of:-  
 $\frac{0.052}{\sqrt{2}} = 18.4$  millivolts.

The primary current through the bore of the 250 mA relay to produce a 50 cycle induced volt per turn of 18.4 mV was measured as 355 mA.

After a period of 10 milliseconds, the value of current drops to:-

$$\text{Induction equivalent to 50 cycles} \\ = \frac{4.3 \times 0.05}{6 \times \sqrt{2}} = 12.8 \text{ millivolts.}$$

representing a primary current of 255 mA.

After a further period of 10 milli-seconds the value of current drops to:-

$$\text{Induction equivalent to 50 cycles} \\ = \frac{1.9 \times 0.05}{6 \times \sqrt{2}} = 5.6 \text{ millivolts.}$$

representing a primary current of approximately 130 mA.

After a total time-lapse of 40 milli-seconds the steady-state induction voltage is:-

$$\frac{0.6 \times 0.05}{3 \times \sqrt{2}} = 3.53 \text{ millivolts.}$$

representing a primary current of 100 milli-amperes.

The frequency, although commencing at 300 cycles/second finally settles to predominantly 150 cycles with a low amplitude component of 300 cycles/second.

We check steady state value by referring to C.R.O. Figure 8:-

Time-base — 10 milliseconds/c.m.

Y deflection — .01 Volts/c.m.

$$\text{Equivalent 50 cycle induction voltage} \\ = \frac{3 \times 0.01}{3 \times \sqrt{2}} = \frac{.03}{6\sqrt{2}} = 3.53 \text{ millivolts.}$$

C.R.O. Figure 7 — Energising Compensator.

This recording shows the core induction of the 250mA relay due to current in the neutral to earth conductor when switching in the compensator on to live busbars with outgoing feeder circuit-breakers closed.

Time-base — 0.5 second/c.m.

Y deflection — 0.05 Volts/c.m.

Here the transient is of long duration. At instant of energising the compensator, we have a complexity of frequencies whose envelope has an amplitude of  $5 \times 0.5 = .25$  Volts peak to peak.

It is difficult to assess the current in the neutral earthing conductor to cause this complex induction but it appears to commence at an effective current of at least 500 milliamperes and decays to a steady state of 100 milliamperes after approximately three seconds.

The Curve 1, I.D.M.T.L. relay in the neutral to earth connection of the compensator operated during energising of the compensator as well as during dropped line tests but remained in-operative during all other tests.

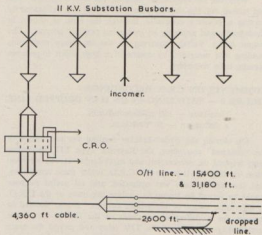


FIG. 19. Vanderbijlpark II K.V. System.

## TESTS AT VANDERBIJLPARK

The 11 kV system at Vanderbijlpark is shown in Figure 19.

In this case, a mu-metal core with multi-turn secondary winding is used as the sensing element. This was mounted as shown in Figure 19 and photograph (Figure 20) below.

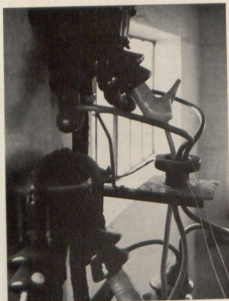


Fig. 20

With the circuit-breaker feeding the test O.H. line open and racked out, the core-balance transformer was calibrated by passing a primary conductor through the bore as shown in photograph, and applying an increasing primary current. The output (r.m.s. Volts) appearing on the secondary multi-turn winding was measured by means of a high input impedance vacuum tube voltmeter.

### COMMENTS ON C.R.O. RECORDINGS:

#### FIGURE 2 — SWITCHING IN ON 11 kV DROPPED LINE

Time-base — 100 milliseconds/c.m.

Y deflection — 50 Volts/c.m.

On closing the circuit-breaker feeding the test line with the "dropped" conductor, the Reyrolle Type TJV protective relay tripped on overcurrent and earth-fault. It was obvious, when viewing the trace on the C.R.O. under these conditions, that the sensing core was saturated, and no useful purpose would be served by trying to analyse the trace of the C.R.O. to determine extent of earth-fault current. It was decided to connect the Y deflection terminals of the C.R.O. across the earth-leakage element of the TJV relay and record the trace when closing in on the test line. From the tripping time recorded, it would then be possible, using the TJV characteris-

tic curves and multiplier settings as well as current-transformer ratio, to assess the earth-fault current.

Figure 2 is a recording of the switching transient, and in line with the reasoning above, the steady-state fault current was calculated to be in excess of 20 amperes.

#### FIGURE 6 — TRANSIENT LEAKAGE ON ENERGISING 11 kV HEALTHY LINE

Time-base — 50 milliseconds/c.m.

Y deflection — 0.01 Volts/c.m.

The transient duration is 150 milliseconds. The earth-leakage current (assessed as before) decays from an initial r.m.s. value of about 100 milliamperes to a steady-state value, after 150 milliseconds, of 25 milliamperes.

#### FIGURES 9 AND 10 — STEADY STATE LEAKAGE ON 11 kV HEALTHY LINE

Time-base — 10 milliseconds/c.m.

Y deflection — .01 Volts/c.m.

Figure 9 is condition with approximately 3 miles of overhead line energised whereas Figure 10 was recorded with 6 miles of line energised.

In both cases, the r.m.s. steady state leakage was assessed to be as low as 25 milliamperes.

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## SAMEVATTING VAN REFERAAAT DEUR

MNR. H. P. SMITH, B.Sc. (ir.)

Die referaat handel oor die gebruik van sensitiewe kern-balansaardlekbeskerming toegepas op bogronde hoogspanningslyne om te voorsien in 'n behoefte wat lank reeds deur elektrengiese ingenieurs aangevoel is. Dit word algemeen aanvaar dat die bestaande aardlekbeveiligingstelsels nie sensitief genoeg is om gebreekte lyne uit te skakel nie. Die vereistes vir 'n aanvaarde relé is gevoeligheid en spoed om teen gebreekte lyne te beveilig sonder om eger in werking te kom met kortsluitings of oorgangsverskynsels. Daar moet ook onderskei kan word tussen volgehoue aardfoute en die van korte duur. Besonderhede word dan verstrekkend van toetse wat gedoen is op 2.2 K.V. en 11 K.V. stelsels en die gevolgtrekking word gemaak dat die relé in werking moet tree by aardlek-foutstrome van minder as 1 ampere en 'n bepaalde minimum tyd van onder 0.5 sekonde.

Besonderhede word ook verstrekkend om aan te toon hoe die beskerming ongevoelig moet staan teenoor foutstrome deur weerligafleiers, die werking van outomatiese sluitskakelaars en sekerings op aftakings.

Dan volg 'n kort beskrywing van die apparaat en hoe die fundamentele waardes van tyd en gevoeligheid ingestel word.

Die gevolgtrekking word gemaak dat nog meer navorsing gedoen sal moet word maar dat die resultate wat reeds verkry is groot belofte inhou vir 'n beveiligingstelsel om bogronde hoogspanningstelsels te beskerm teen die gevare van gebreekte lyne.

